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Content

Biological sciences

<i>Jamila Murtuza Aliyeva, Maya Nabi Farzaliyeva, Arzu Sakhat Ismayilova</i> MESENCHYMAL STEM CELLS: ANTIMICROBIAL AND IMMUNOMODULATORY EFFECTS	3
<i>Dilnoza Maxammadiyeva, Gulsanam Alimova, Elmurod Khudoyberdiev, Begali Alikulov</i> BIOCHEMICAL BASIS OF STRESS RESISTANCE OF ENDOPHYTIC BACTERIA	5
<i>Ulughbek Nijozov, Ilxom Mukumov, Murtoza Hasanov</i> PARTS AND UTILITY VALUE OF MEDICINAL PLANTS USED IN GELAN VILLAGE	8

Economic sciences

<i>Mammadova Afat Mammadhuseyn, Ibrahimli Habib Yusuf</i> ARTIFICIAL INTELLIGENCE AS A TOOL FOR DATA-DRIVEN URBAN PLANNING IN SMART CITIES	10
<i>Mira Andoni</i> INNOVATION DEVELOPMENT IN ALBANIA: CHALLENGES, ADOPTION PATTERNS, AND POLICY PERSPECTIVES	19

Historical sciences

<i>Nigar Ali Gasimova, Elshad Altay Bagirov</i> ZOOMORPHIC REPRESENTATIONS OF EVEN-TOED UNGULATES ON GLAZED CERAMICS OF THE SELJUK PERIOD IN AZERBAIJAN	23
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Medical sciences

<i>Ali Ismailzade</i> DIABETES MELLITUS AS A CHALLENGE OF THE 21ST CENTURY: MODERN APPROACHES TO DIAGNOSIS, TREATMENT, AND PREVENTION	30
<i>Arman Khozhayev, Aida Zinashova, Diana Akhayeveva, Asemay Kydyrbaeva, Aruzhan Yerbolatova, Diana Aitzhanova, Sezim Beketkalikyzy, Tomiris Adilbek, Zarina Anarkulova</i> PANCREATIC CANCER: MODERN REALITIES AND TRENDS	37

Pedagogical sciences

<i>Yerlan Akmaral Yerlankyzy</i> DEVELOPING INTERCULTURAL COMPETENCE THROUGH TOPONYMIC PHRASEOLOGICAL UNITS IN EFL CLASSROOM	48
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Philological sciences

<i>Konul Tagiyeva, Gunay Abdullayeva, Elnura Gasimova, Ayshen Abbasalizade</i> STUDY OF THE INTERRELATIONS BETWEEN LANGUAGE AND CULTURE	51
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Technical sciences

<i>Amangeldy Farhad, Oksikbay Nurdaulet, Orazgaliev Dauren, Kauymbaev Rakhimzhan</i> SMART CITY TECHNOLOGY, PROBLEMS OF STANDARDIZATION AND INTRODUCTION IN CIRCULATION	55
<i>Amangeldy Farhad, Oksikbay Nurdaulet, Orazgaliev Dauren, Kauymbaev Rakhimzhan</i> THE PROCESS PATH OF ENTERPRISE MANAGEMENT: ADVANTAGES AND PROSPECTS	59
<i>Mirzayev Razil Tofiq, Mirzayev Tofiq Haji, Mammadov Elchin Pasha</i> STUDY OF THE ABRASION RESISTANCE OF SEWING THREADS USED IN THE INDUSTRY	62

Biological sciences

MESENCHYMAL STEM CELLS: ANTIMICROBIAL AND IMMUNOMODULATORY EFFECTS

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Abstract

In recent years, the rapid increase in antimicrobial resistance has become a major global health concern, highlighting the urgent need for alternative therapeutic strategies for the treatment of infectious diseases [1]. In this context, mesenchymal stem cells (MSCs) have attracted significant attention not only because of their regenerative capacity but also due to their antimicrobial and immunomodulatory properties [1,2]. Experimental and preclinical studies have demonstrated that MSCs can exert antimicrobial effects through the secretion of antimicrobial peptides, modulation of immune cell activity, and regulation of inflammatory cytokine balance [3,4]. In animal models of sepsis and bacterial infections, MSC therapy has been shown to reduce bacterial burden, attenuate tissue damage, and improve survival rates [5,6]. This review summarizes current evidence on the antimicrobial and immunomodulatory mechanisms of mesenchymal stem cells and discusses their potential clinical applications in the treatment of infectious diseases.

Introduction

Mesenchymal stem cells are multipotent stromal cells that can be isolated from various tissues, including bone marrow, adipose tissue, and umbilical cord [1,2]. Due to their low immunogenicity and immunomodulatory potential, MSCs are considered promising candidates for clinical applications [3]. Over the past decade, increasing evidence has shown that MSCs play an important role in regulating immune responses and influencing the course of infectious diseases [3].

The growing prevalence of antibiotic-resistant pathogens has limited the effectiveness of conventional antimicrobial therapies and necessitated the development of innovative treatment approaches [1]. Unlike traditional antibiotics, MSCs do not act solely by directly targeting pathogens but rather by modulating host immune responses and enhancing endogenous antimicrobial mechanisms [4]. Therefore, MSC-based therapies may represent a novel and complementary strategy for the management of infectious and inflammatory conditions.

Antimicrobial mechanisms of mesenchymal stem cells

The antimicrobial effects of MSCs are mediated through both direct and indirect mechanisms. Direct antimicrobial activity involves the secretion of antimicrobial peptides such as LL-37, β -defensins, and lipocalin-2, which disrupt microbial cell membranes and inhibit the growth of a wide range of bacterial pathogens [4,8]. Indirect antimicrobial effects are associated with the modulation of innate immune cells. MSCs enhance the phagocytic activity of macrophages, promote neutrophil migration, and support pathogen clearance [5].

Immunomodulatory effects

MSCs play a crucial role in balancing immune responses by regulating the production of pro- and anti-inflammatory cytokines. They suppress the release of proinflammatory cytokines such as tumor necrosis factor-alpha (TNF- α), interleukin-6 (IL-6), and interferon-gamma (IFN- γ), while promoting the secretion of anti-inflammatory mediators including interleukin-10 (IL-10) and transforming growth factor-beta (TGF- β) [3]. This immunomodulatory capacity is particularly important in severe infections and sepsis, where uncontrolled inflammation can lead to tissue damage and organ failure [6].

Experimental and preclinical evidence

Numerous animal studies have demonstrated the therapeutic potential of MSCs in models of bacterial sepsis, pneumonia, and wound infections. Administration of MSCs has been shown to significantly reduce bacterial load, decrease inflammatory tissue injury, and improve survival rates [5–7]. These findings support the concept that MSCs exert both antimicrobial and tissue-protective effects in infectious disease settings.

Clinical application perspectives

MSCs are currently being investigated as potential therapeutic agents for sepsis, chronic wounds, burn-related infections, and pulmonary infections [6,7]. Early-phase clinical trials suggest that MSC

therapy may be safe and beneficial when used as an adjunct to standard antimicrobial treatments. However, further randomized controlled clinical trials are required to determine optimal dosing, administration routes, and long-term safety [2].

Conclusion

Based on the analysis of current literature, mesenchymal stem cells represent a promising therapeutic approach with significant antimicrobial and immunomodulatory potential [1–3]. Preclinical studies provide strong evidence supporting their effectiveness in the treatment of infectious diseases [5–7]. Nevertheless, large-scale and well-designed clinical trials are necessary to confirm their clinical efficacy and establish standardized treatment protocols.

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BIOCHEMICAL BASIS OF STRESS RESISTANCE OF ENDOPHYTIC BACTERIA**Dilnoza Maxammadieva***Institute of Biochemistry, Samarkand State University
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In developed countries of the world, special attention is paid to the study of secondary metabolites of bacteria and the use of isolated metabolites in various industries. In this regard, it has been noted that plants growing under conditions of stress have great potential as a source of bacteria from which rare metabolites can be isolated. It is important to isolate the metabolites of endophytic bacteria, assess their composition, classification and biotechnological potential. Below is an analysis of some groups that endophytic bacteria produce to mitigate the effects of stress factors.

Antioxidants. When osmotic and salinity stress occurs, various types of volatile oxygen are formed in plants. The oxidation of membrane proteins, lipids or DNA is carried out by several enzymes, including catalase, superoxide dismutase and ascorbate peroxidase. Microorganisms use similar methods to combat oxidative stress. In 2012, Hamilton and colleagues reported the production of volatile oxygen by endophytic fungi in plants [1].

In this regard, studies have shown a correlation between plant tolerance to salinity stress and a decrease in the activity of antioxidant enzymes [2]. Volatile oxygen species scavengers include superoxide dismutase, catalase, ascorbate or thiol-dependent peroxidase, glutathione reductase, dehydroascorbate reductase and monodehydroascorbate reductase, as well as glutathione, ascorbate and tocopherols [3]. They participate in the degradation of volatile oxygen species either directly (superoxide dismutase, catalase, ascorbate peroxidase) or indirectly by regenerating ascorbate and glutathione in the cell. Rodriguez et al. (2008) found that the non-symbiotic plant *Leymus mollis* (sandweed) was severely wilted within 7 days and died after 14 days when continuously exposed to 500 mmol/L NaCl solution, while plants treated with *Fusarium culmorum* were not exposed to 500 mmol/L NaCl solution for 14 days [4].

In another study, experts have proven that the endophyte *P. indica* increases the amount of antioxidants in barley plants and provides the plant with salt tolerance [5].

Soluble substances. If Na⁺ and Cl⁻ ions are reduced in the vacuole of a plant cell, organic solutes that are resistant to metabolic activity even at high concentrations accumulate in the cytoplasm and organelles to balance the osmotic pressure of the ions in the vacuole. In this case, the compounds that accumulate most in the cell are proline, glycine-betaine, and sucrose. The accumulation of organic solutes is an important mechanism for combating osmotic stress, and this phenomenon has also been studied in halophytes. It has been proven that after endophytic colonization of plants, the amino acid proline, under the influence of bacteria, increases the plant's tolerance to salinity. However, previous studies, as a result of experiments with fungi, have noted that the accumulation of proline is not the cause of salinity tolerance, but rather a consequence [6]. Osmoregulation can also be provided by carbohydrates (sugars) and betaines. Osmoregulation by carbohydrates (sugars) and betaines has been studied in mycorrhizal plants, and the use of these substances has been recommended to increase salinity tolerance [7]. It has been proven that rice plants can be grown under saline conditions by stimulating the accumulation of high concentrations of glycine-betaine-like substances by the endophytic bacteria *Pseudomonas pseudocaligenes* [8].

Exopolysaccharides. Halotolerant and halophilic bacteria secrete EPS, which are necessary for attachment to the root surface or soil particles. They play an important role in the interaction of bacteria and microorganisms, in cell association between them, and in protecting plant tissues from the effects of bacteria, viruses, and protozoa [9, 10]. EPS is involved in stabilizing soil structure and ensuring the water-holding capacity of soil particles. It has been noted by experts that treatment with halophilic

bacteria *Halomonas*, *Halobacillus*, and *Planococcus* enhanced the growth of wheat, *Sesuvium portulacastrum*, and pea under saline conditions [11].

Halocins. Halocins are protein bacteriocins produced by extremely halophilic bacteria and archaea. Halocins are divided into two types: (1) microhalocins (peptides) smaller than 10 kDa and (2) macroprotein halocins greater than 10 kDa. Their bactericidal modes of action are broad. In particular, they can inhibit DNA and RNA nuclease activity, transcription and translation, induce pore formation in the cell, and cause bacteriolysis [12-14]. Not all halobacteria and archaea are capable of producing specific halocins. Halocins were first isolated and characterized from *Haloferax* sp. (Halocin H4). To date, halocins G1, R1, A2, H6, C8, and A4 have been studied at the molecular level [15]. High-throughput sequencing methods have shown that halocins have a positive effect on plant traits and increase plant tolerance to salinity. Bacteriocin thuriengenesis, a bacteriocin 17, produced by the bacterium *Bacillus thuriengenesis*, differentially altered the growth characteristics of *Arabidopsis thaliana* under salinity conditions (200 mM NaCl). Several plant proteins are involved in carbon and energy metabolism, and their activity can be regulated by bacterial effects, including halocins [16].

Volatile organic compounds and polyamines. Both ROS and endophytic bacterial strains produce volatile organic compounds that modulate salinity and drought stress and promote plant growth. Inoculation of wheat plants with *Bacillus*, *Pseudomonas*, and *Halomonas* strains resulted in increased plant biomass, reduced volatiles, and increased photosynthetic rates. *Bacillus subtilis* strains that produce volatile compounds regulate Na-dependent homeostasis in *Arabidopsis thaliana* under salinity stress [17, 18]. These compounds are incorporated into proline and chlorophyll and contribute to plant homeostasis by reducing Na⁺ accumulation in roots. Polyamines secreted by ROS and endophytic bacteria have a positive effect on reducing osmotic stress in plants. Studies have shown that inoculation of *Arabidopsis thaliana* with *Bacillus megaterium* strain BOFC15 increased the amount of polyamines in the plant and helped reduce osmotic stress [19].

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PARTS AND UTILITY VALUE OF MEDICINAL PLANTS USED IN GELAN VILLAGE

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Introduction. Humanity has historically benefited greatly from plant species. Understanding how indigenous communities engage in resource use, particularly for healing and therapeutic purposes, is increasingly being explored through scientific research on these plants (1,2,3). Indeed, ethnobotanical research has paved the way for the discovery of synthetic and natural medicines (4,5). In recent times, many successful drug testing initiatives have been based on ethnobotanical knowledge (6).

The use of plants as traditional medicine is a long-standing practice among the people of Gelan village, Shahrisabz district, Kashkadarya region, Uzbekistan. This study aimed to determine the diversity of medicinal plant species, plant parts used, processing methods, and how plants are used as traditional medicines.

This study focuses on the diversity of medicinal plants, the parts of the plants used, the processing methods, and their use as traditional medicines in Gelan village (West Hissar region, Shahrisabz district). This study may become a valuable resource for future ethnobotanical research (7,8).

Results and Discussion. The parts of medicinal plants used were categorized as leaves, flowers, roots, seeds, fruits, grains, stem bark, stems, and oils. Overall, leaves (42.1%) were the most commonly used parts in the treatment of diseases in Gelan, followed by roots (21.05%), fruits (12.63%), seeds (8.42%), flowers (6.31%), stems (5.26%), grains, stem bark, and oils (1.05% each) (Figure 1).

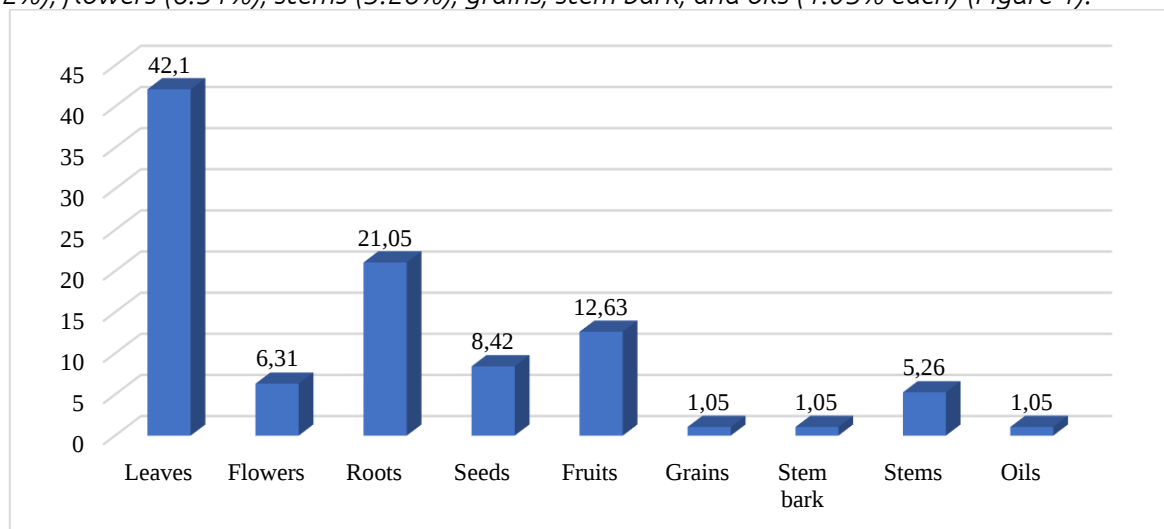


Figure 1. Plant parts used in folk medicine in Gelan.

The analysis of the relative importance of medicinal plant use was based on the total number of informants who specifically used a particular plant species. The UV value for medicinal plants in the village ranged from 0.00 to 1.00. Based on the number of plant species with UV values up to 1.00 in the village, 10 plant species with values up to 1.00 were identified in Gelan.

The results of this study showed that the highest UV values in Gelan village were recorded for the following plant species: *Ferula sumbul* (0.85), *Dianthus caryophyllus* and *Rhodiola rosea* (0.82), *Campanula latifolia* (0.80). These are followed by *Rheum officinale* and *Rosa canina* (0.78), *Juglans regia* (0.75), *Amygdalus communis* (0.73), *Ziziphora persica* and *Rubia tinctorum* (each 0.70) (Figure 2).

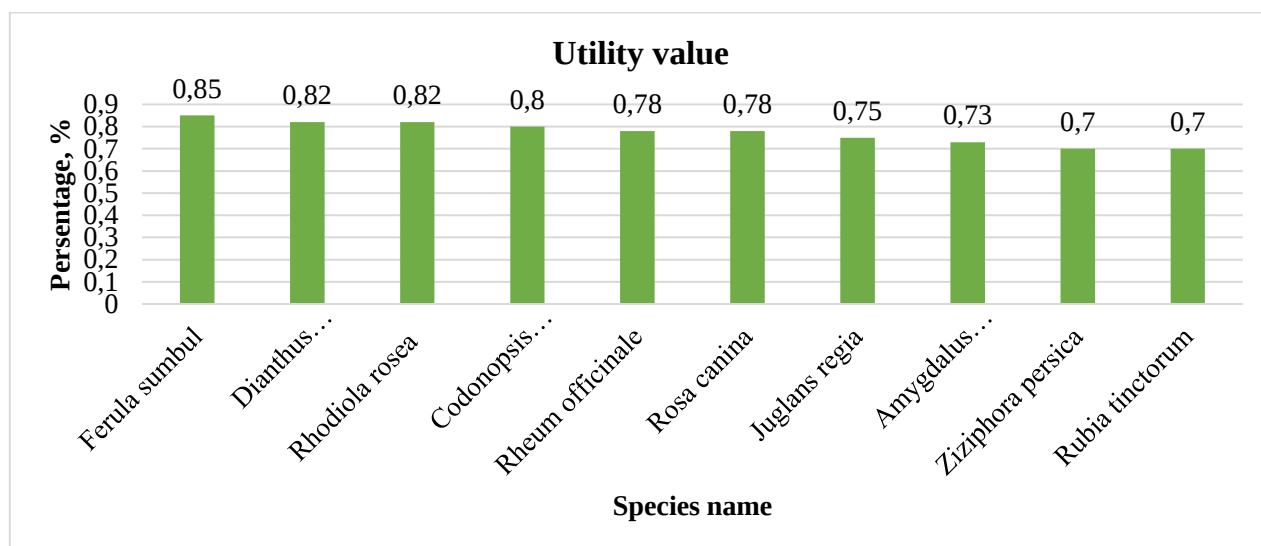


Figure 2. Plant species with the highest utility value (UV)

Conclusion. Most informants mentioned several plant parts used for medicinal purposes, including leaves, fruits, roots, stems, barks, flowers, and seeds. Sometimes, mixtures of different plant parts were prepared to increase the effectiveness of the treatment.

According to the results of the utility value (UV) analysis, the most commonly used medicinal plants in folk medicine practice in Gelan were evaluated as follows: *Ferula sumbul* (0.85), *Dianthus caryophyllus* and *Rhodiola rosea* (0.82), *Campanula latifolia* (0.80), *Rheum officinale* and *Rosa canina* (0.78), *Juglans regia* (0.75), *Amygdalus communis* (0.73), *Ziziphora persica* and *Rubia tinctorum* (0.70) (Figure 2). Traditional healers commonly use these 10 medicinal plants to treat respiratory diseases (cough, bronchitis, asthma, angina) and hypertension, as well as for the treatment of middle-aged and elderly people. According to the results of the interviews, these plants are usually grown wild or purchased directly from rural markets.

According to the utility value (UV), the 10 plants with the highest UV were identified as *Ferula sumbul*, *Dianthus caryophyllus*, *Rhodiola rosea*, *Campanula latifolia*, *Rheum officinale*, *Rosa canina*, *Juglans regia*, *Amygdalus communis*, *Ziziphora persica*, *Rubia tinctorum*.

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Economic sciences

ARTIFICIAL INTELLIGENCE AS A TOOL FOR DATA-DRIVEN URBAN PLANNING IN SMART CITIES

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Abstract

Fast city expansions make city planning harder today. Old ways of thinking – using fixed numbers and slow predictions - cannot handle shifting problems like clogged roads, harmed nature, wasted space, or poor service gaps. Here comes artificial intelligence: turning real-time data into smarter town designs for urban areas.

This piece looks at how artificial intelligence reshapes city planning by using vast amounts of information, forecasting tools, and self-run advisory platforms. Instead of just listing tools, it focuses on spaces like moving people around, adjusting building density, tracking nature's health, and handling core facilities. Tools like machine learning, image analysis, and connected brain-like systems help experts break down tangled city layouts and test what might come next - better than old-style approaches ever could.

Looking at past work, the document checks some smart city examples using AI in planning. What stands out shows what helps and what does not. Focus lands on problems like private data risks, reliance on tech tools, moral questions, along with gaps between city parts.

Results point toward big chances for smarter cities when AI is used right - clear rules plus people-first planning matter. So instead of seeing AI replace planners, it works better as a sharp helper for making smarter choices about urban growth. Thought of this way, tech assists, does not take over shaping more livable futures.

Keywords: *Artificial Intelligence, Smart Cities, Urban Planning, Data-Driven, Design, Machine Learning, Sustainable Development, Urban Analytics.*

Introduction

Cities are changing fast because people move to them quicker than ever before. Over fifty percent of everyone on Earth now calls an urban place home, a number likely to climb without stopping. When city life grows denser and tangled with time, deciding where things go gets harder - roads fill, nature fades, fairness wavers, movement slows, supplies run thin. Outdated methods - rooted in fixed data, long-range forecasts, still today's reality - struggle more and more when facing complex city life, where constant change drives outcomes beyond old tools' grasp.

Facing growing difficulties, cities began exploring new ways to function better. Instead of old methods, they turned toward digital tools and live data feeds. Technology now helps manage traffic, energy use, and services without delays.

People feel changes - like cleaner parks or faster help when something breaks. Behind scenes, networks track waste patterns or adjust street lighting automatically. Life gets slightly smoother because systems respond quicker than before [4], [5]. Still, managing bigger and messier city data needs sharper thinking tools - ones that spot trends, guess what comes next, while guiding key choices. That push led AI right into the heart of shaping smarter cities.

Computers now handle work once thought only people could do - things like seeing patterns, making decisions, solving problems, or understanding language [1], [7].

When it comes to designing cities, tech like pattern-finding machines, brain-inspired circuits, image-scanning software, and forecast-based tools digs into mountains of info collected by gadgets, space probes, phones, and government files. Instead of just reporting facts, these systems begin testing possible

futures - mapping how neighborhoods might grow, adjusting where buildings go, smoothing daily travel chaos, while reducing harm to nature and air.

1. The key role of AI in smart cities

Artificial intelligence plays a key role in smart cities, acting as a central tool for big data analysis and automation of urban infrastructure management. It integrates data from sensors, cameras, and IoT devices, providing real-time decision-making to optimize transportation, energy, and security. Central functions: AI creates digital counterparts of cities, predicting loads and development scenarios, as in the projects of Singapore, Barcelona, Helsinki. It optimizes traffic, allocates resources, and monitors the environment, reducing traffic jams and energy costs. Strategic importance Improves the quality of life through automation of services, healthcare and utilities. Provides stability and safety, including facial recognition and pollution control. It promotes digital sovereignty and innovation in urban planning.

Now think about how cities are usually planned. This method moves away from oldschool approaches using only past numbers and rigid blueprints. Real-time details now allow changes as urban life shifts [5], [9]. Take smart traffic systems – they modify light changes instantly depending on actual traffic pressure. Meanwhile, forecasting tools hint at future population trends, shaping where buildings go. When it comes to smart cities, machines backed by artificial intelligence now track things like dirty air or loud sounds - also how much power gets used. Out of that kind of data, better long-term planning begins to take shape. What makes AI useful in city design? Its ability to handle vast, linked datasets. Not just numbers - real-world complexity. Thinking of traffic patterns shifting alongside rent prices, air quality, job zones, community needs. These forces mix deeply. Old methods fall short when connections get tangled. Using artificial intelligence helps spot links that are hard to see, while also creating different versions of how cities might grow. These tools support smarter decisions over time, because they reduce the risk tied to big city plans made far ahead.

Still, AI helps make planning more shared and inclusive. Using tools like data maps, virtual city models, or live interactive demos, people involved grasp how choices affect communities. A digital twin - a real place copied online - lets designers explore different layouts safely in a test space, then apply only what works later. Cities start seeing clearer results when they put AI into planning tools. This shift helps assess how new projects affect people, money, and nature - without hiding gaps in reasoning.

When it comes to building design, small choices now shape how cities grow later. Using weather or traffic info helps plan streets and homes more efficiently. Instead of guessing, algorithms guide decisions about window placement or shared courtyards. These tools adapt as people move through neighborhoods over time. Efficiency often follows when systems learn from real activity. Here, AI shifts from being just software into something that reshapes how cities are thought about and built.

This work looks at how artificial intelligence supports planning in city areas using data. Instead of just theory, it digs into real examples across different areas of city design. Some projects already use machine learning tools to manage traffic or plan green spaces. By reviewing specific situations where tech helped decide layouts, patterns emerge about what works. Still, there are downsides like privacy concerns or bias in algorithms. Even so, progress suggests smarter, more livable cities might come from such tools. Looking closely at tech and physical space ways people take up AI, the study aims to shed clearer light on its part in today's city growth.

2. Literature Review

2.1 Evolution of the Smart City Concept

Over twenty years, what we call a smart city has shifted - shaped by advances in tech, how cities manage themselves, and what people actually require. At first, the vision mainly linked to embedding info tech into city systems [4]. Back then, people saw it as using digital grids, sensors, machines to make urban life smoother: getting around easier, power spread more reliably, help available faster. Often missing from tech-focused solutions are considerations of how cities actually function - people, places, relationships come first.

What counts as a smart city changed slowly, moving past just tech fixes. Today's views put emphasis on lasting patterns, community voice, local economies, and daily well-being. Many now see cities as layered mixes of social and digital elements - where innovation serves real people. Here, smart cities go beyond tech tools – they show clear planning, care for nature, follow fair rules, and treat everyone fairly.

City life now runs on numbers more than roads. Sensors dot neighborhoods, phones track movements, digital systems store activity across districts [5]. Because of this flood of details, how towns operate is changing - less about building bridges, instead relying on patterns hidden in digital flows. Decisions once shaped by engineers walking streets now form through spreadsheets lighting up screens late into nights.

2.2 Development of AI Technologies in the Urban Context

Lately, Artificial Intelligence has moved fast because computers are stronger now, more data exists, yet better algorithms play a role too [1]. Instead of just processing numbers, machines learn patterns - like spotting objects in photos or forecasting outcomes - thanks to tools like machine learning, deep learning, along with layered brain-inspired networks. Cities are changing how people live, work, move because of these shifts.

City planners now rely on artificial intelligence to study vast amounts of information about how people move, where power flows, air quality, and daily habits unfold.

Instead of guessing, they let software learn from traffic sensor readings plus GPS logs, shaping forecasts for busy roads by adjusting signal phases on the fly [2]. In a different arena, digital overseers of energy systems scan household and building usage numbers, adjusting distribution networks so less electricity vanishes unnoticed.

Cities once planned using paper-based methods now face new insights from artificial intelligence [7]. Instead of fixed forecasts, systems guess how neighborhoods might expand. These guesses help spot where crowds could build up over time. Nature too feels shifts - pollution, heat waves, noise shift into predicted patterns. Cameras and sensors trained on images from space allow faster drawings of city edges. What was once done by hand or sketchpad now happens without human touch. Now imagine AI shaping decisions before problems even start. That shift - seen clearly here - turns planning into something active, forward-thinking, almost reading what comes next.

2.3 Data-Driven Urbanism

City planning shifts when numbers guide decisions. Real-time data replaces old methods based on past trends or fixed blueprints. Tools like sensors, app usage, and online platforms feed city systems with live inputs. With these inputs, adjustments happen faster, responses become sharper.

What shapes cities today often passes through artificial intelligence first. Handling vast amounts of urban information becomes manageable thanks to smart systems [5].

Instead of guessing, decisions now rest on data shaped by machines learning from patterns. People design places differently when they see how people move, where buildings go, or if air stays clean. Seeing what comes next gets clearer because models track trends across time and space. Using data helps build digital twins - online copies of city spaces. These copies pull information from various places, mimicking how cities work. Simulation tools let city planners explore different futures through trial runs. When combined with artificial intelligence, virtual models check how ideas might play out in the physical world.

Using modular units cuts dangers while boosting how well cities function under stress. Still, using data in cities brings fresh problems [9]. Depending too much on digital systems makes people worry about private information, online safety, and being overly tied to tech. On top of that, when not everyone has equal digital tools, gaps grow between city neighborhoods. What stands out is how crucial fair and responsible AI methods have become for planning.

2.4 Existing Research Gaps

Even though more studies come out about smart cities and artificial intelligence, clear gaps still exist. Most current work looks at technology rollout and system performance, yet how AI shapes city layout and buildings stays underexamined. What lacks are investigations into whether AI changes neighborhood character, park layout, or daily life inside urban areas [3].

A different missing piece ties to how traditional planning methods connect with artificial intelligence tools. Even though several test programs and proof-of-concept efforts show what AI might do, studying on smoothly embedding such tech into everyday procedures and legal structures stays rare. Issues around who decides, who is responsible, and how different fields work together still lack clear answers.

Still, talks about ethics tend to stay vague, skipping real-world consequences [8].

Things like algorithmic bias, who owns data, or clear disclosure need closer looks - especially when city choices shape many lives.

This study tackles those missing pieces by looking at AI - not just as tech - but also as a way to shape cities. Instead of treating it narrowly, it explores how AI fits into real planning work. Its effects on architecture are considered alongside what it might do for green, fairer urban futures.

3. Methodology

Looking at cities with smart tech, this work uses qualitative methods to explore how artificial intelligence shapes planning decisions based on data. Because city design involves many fields of knowledge, the research blends idea discussions, examples across places, and close-up studies to grasp how AI fits into real-world city blueprints [7], [8].

A look begins with checking past studies on smart cities, how AI uses city data, and digital management. Books, journal pieces, and official reports got examined to spot dominant ideas, tech shifts, and missing pieces. This part sets the thinking base for the work while tracing how AI grew in city design decisions.

Next comes sorting and analyzing AI tools within major city planning areas like traffic networks, zoning rules, tracking nature changes, and handling public works.

Because these topics fit well with digital urban design and real-world AI use cases, they were chosen for study. Within every field examined, attention goes to what kind of artificial intelligence gets deployed, what kind of information gets used, along with results seen in how cities function.

In stage three, real-world examples are studied through case analyses. Cities that used artificial intelligence in city planning are looked at closely to see how well it worked. For this review, places were selected based on clear standards. Those cities fit specific research needs around effective tech integration.

- 1. Documented use of AI technologies in planning processes,*
- 2. Publicly available data or reports accessible to everyone*
- 3. How it fits into sustainable and big-city urban growth.*

Looking at multiple examples side by side helps spot what works alike and what stands apart across projects. This method also reveals which approaches hold up well and where methods fall short. Comparisons reveal both useful patterns and tricky issues tied to using artificial intelligence in real settings.

Looking at how well AI works in city planning, the study uses things like whether processes run smoother, greener solutions grow stronger, flexibility increases, decisions become clearer, and more people feel included. Even though some numeric measures are mentioned now and then, the main goal lies elsewhere - in seeing how deeply AI changes planning's shape and direction instead of building math-heavy forecasts.

Looking back, the work recognizes a few drawbacks. With fast changes in AI, certain setups could be early trials instead of complete solutions. On top, getting clear technical information might differ between cities, which could shape how thoroughly results are compared.

4. Applications of AI in Urban Planning

Out in city planning today, Artificial Intelligence plays a key role - especially in smart cities. With help from real-time and past data, big and small, systems get broken down faster. This lets those who plan cities see what works, adjust on the fly, leave less waste behind. From roads to zoning rules, even green spaces and water networks, algorithms quietly shape decisions now. In every of these fields, artificial intelligence turns old-fashioned forecasting into sharp, fact-based predictions.

4.1 AI in Transportation and Mobility

What moves cities often leaves behind piles of digital trail. From the rhythm of daily commutes to where buses go and how people walk, loads of data pile up. Artificial intelligence doesn't just swallow it - it makes sense of it. Patterns in road use reveal bottlenecks before they happen. Traffic lights adjust on their own when learning models track real-time demand. Paths through busy zones shift smarter with algorithms that map human behavior.

Traffic lights change on their own using live info from sensors, cameras, and GPS tools - no fixed plan. Because adjustments happen second by second, roads stay less crowded and trips take shorter walks across town. Less driving around searching for open lanes means fewer gallons burned mid-fuel tank. Public buses and trains lean into artificial intelligence now, spotting how many travelers might show up next hour.

Scheduling shifts follow those guesses without delay, smoothing daily movement through crowded neighborhoods. Take traffic patterns during busy times – knowing when people travel helps change how often buses run, making trips smoother while using fewer vehicles.

On top of that, artificial intelligence helps shape independent and partly automatic transportation setups. Computer vision, along with neural networks and combined sensor data, guides self-driving cars through crowded city streets. Even though complete autonomy hasn't yet arrived, smart mobility systems powered by machine learning are starting to shape choices in building roads, managing parking, and organizing traffic flow.

4.2 AI in Land Use Optimization

What happens on the ground depends heavily on how cities are planned. Instead of fixed rules based only on numbers and forecasts, new methods now consider real-time patterns in where people live,

move, work, and play. By digging into vast amounts of information about housing density, travel behavior, job markets, and nature's limits, artificial intelligence helps shape smarter environments.

Out in the field, computers spot shifts in where people live, opening views into where things might go next. When city designers try out various rules about building use, tools quietly check traffic loads or strain on services. Imagine changing a whole neighborhood's layout - software runs numbers on nature, movement, resource pulls.

Say you boost homes near centers - models show heat, transit needs, soil shifts before decisions harden.

Out here, artificial intelligence backs up smart planning methods. When you set up space, surroundings, and community factors, algorithms shift into gear – offering varied designs on the fly. Each option pops up, tested against standards like ease of access or power use. Quality of shared outdoor areas gets checked too, no matter the route taken. Because of this change, artificial intelligence helps shape smarter land uses - ones that shift easily when cities evolve.

4.3 AI in Environmental Monitoring

One key goal of smart cities ties back to nature's balance. City life brings tough conditions on earth's systems - smoke in the air, sweltering streets, constant sounds, power that wastes. Tools built from artificial intelligence help track, study, then steer these pressures toward better outcomes.

From cities wide, data flows through sensors powered by artificial intelligence. Air purity, heat waves, moisture levels, sound volumes - each tracked in real time. Out of vast streams of information, hidden trends begin to show themselves. Patterns emerge where before there were only guesses. Predictions take shape not through rules but through repeated learning. Unknown emissions can now be traced back to specific places. Risks that once went unseen start to surface with clarity. Take forecasts, where machines guess when dirty air might hit - using storms, roads full of cars, factories. Sometimes they spot it coming.

On top of that, artificial intelligence helps save energy in structures along with city planning elements. Energy distribution shifts smoothly when smart grids apply machine learning methods - this cuts down excess consumption while boosting performance. Heating, cooling, and lighting shifts occur inside buildings once managed by AI learns who is present and what the skies hold. These tech tools help cut energy use while shrinking pollution output.

When cities adjust their layout using climate insights, artificial intelligence plays a role. Instead of guessing, planners now examine real-world weather patterns through smart algorithms. These systems suggest where trees might help cool streets, which direction buildings face to catch breezes, or what materials reduce heat absorption. Decisions once based on assumptions shift toward data-driven suggestions. Urban spaces become more adaptable, resilient, and energy-aware when guided by such digital tools.

4.4 AI in Infrastructure and Public Services

What holds a city together? Its pipes, trash routes, power lines, and shared spaces. These pieces run nonstop, needing steady oversight. With smarter tools now available, patterns can be spotted ahead of time - guiding choices without human delay.

Ahead of breakdowns, cities gain by spotting issues early through smart tracking. Instead of waiting, systems watch sensor signals from roads, bridges, pipes, and power lines using artificial intelligence tools. Patterns noticed by these algorithms reveal subtle damage long before it causes trouble. When problems arise later, repairs tend to cost less and stop less service overall.

From trash piles to smarter cities - artificial intelligence now helps run waste systems. Bins with built-in sensors track how full they are, sending real-time data to artificial intelligence networks that adjust pickup schedules on the fly. Less driving around means lower emissions, less fuel used, and trimmed budgets for municipalities. Just like that, machines learning how people handle water might catch leaks while tracking what gets used each day. Sometimes they even adjust where and when water flows.

When it comes to public service, artificial intelligence helps cities stay safer during crises. Footage from cameras gets scanned by smart software that spots odd behavior, crashes on roads, or too many people in one place. Instead of reacting late, rescue teams lean on data-driven forecasts built into algorithms designed to flag dangerous zones ahead of time.

What stands out is how AI helps build digital platforms for city management. These tools pull together information from different city services, letting officials track key metrics while handling problems as they happen. Thanks to automated analysis, government operations become faster, clearer, and more alert to change.

5. Case Studies of Smart Cities

Picture a city where traffic flows through machine learning algorithms. Real towns already show how this works - not always smoothly. Some use computer models to plan parks; others let crowdsourced ideas shape road construction. Each example reveals both gains and hiccups in using numbers to shape neighborhoods. What stands out is not the tech itself but the choices made across varied urban experiments.

5.1 Singapore: AI-Driven Urban Management

Known for its forward thinking, Singapore stands among the top smart cities globally. Within this city-state, artificial intelligence supports key areas like mobility, urban zoning, pollution tracking, and government operations. A broad digital plan drives these efforts through the Smart Nation program. A major part of Singapore's method involves creating a digital duplicate called Virtual Singapore. This 3D dynamic model pulls together geospatial details, natural surroundings, and built systems to mimic city life. Using artificial intelligence, patterns in how people move, live density levels, and power use get studied inside the system. Because of this setup, city designers can explore future plans safely, ahead of actual construction. Take city planning - models today might check how fresh skyscrapers shift air movement, light reach, or road usage.

Out on the roads, artificial intelligence digs into live traffic updates to adjust traffic signals for better flow. In cities with homes, number crunching shapes where new buildings go based on population patterns and income levels. What emerges is a way forward for long-range living spaces, guided by solid insights from social and demographic information. What stands out about Singapore is the way central planning meets robust digital systems, shaping thoughtful uses of AI within city design.

5.2 Barcelona: Data-Driven Urban Services

Barcelona shapes its smart city approach around shared control and community voice. Instead of central authority, tools like artificial intelligence track traffic patterns or manage waste disposal. Data streams flow into systems that adjust street lighting based on real-time use. Efficiency grows quietly through smarter transportation routing during peak hours. From sensors across the city, Barcelona gathers live information about roads, trash levels, streetlights, and air quality through connected devices. Instead of fixed schedules, trash trucks now follow routes guided by sensor data on how full containers are - cutting expenses while lowering pollution. On busy walk paths, smart lamps shift their glow levels automatically, using less power when fewer people move by.

Barcelona pushes open data so people can look up city records easily. Because of that, scientists and regular folks get real access to numbers about how the town runs. Seeing what's inside helps shape decisions together with neighbors and thinkers alike. Even though artificial intelligence gets used more through local offices than in one main hub like in Singapore, it shows a way forward - where tech guides fairer choices in city life.

5.3 Helsinki: AI and Participatory Urban Planning

In Helsinki, planning takes shape through shared decisions paired with artificial intelligence. Tools rooted in data analysis help city officials test zoning rules while exploring climate solutions. New building projects are reviewed using smart simulations that measure environmental impact - things like power consumption and pollution output.

In Helsinki, artificial intelligence shapes how people move around town. One example is how MaaS platforms use travel data to connect different modes of transport. Public buses, bike rentals, or ride hailing come together through one digital interface. Because of this, fewer rely on solo driving each day. Cities like this see smarter ways to get places without more pollution.

5.4 Comparative Analysis

One thing stands out across the examples - how decisions get made differs each time. In Singapore, control rests tightly within state structures, tied closely to digital infrastructure. AI lives alongside long-term national strategies there. Barcelona takes another path, centering services around people while keeping outcomes visible and environmentally aware. Helsinki shows how AI works alongside community input while adapting to environmental needs.

Despite contextual differences, several common patterns emerge:

1. Heavy use of city data on a big scale
2. integration of AI into mobility and infrastructure systems
3. emphasis on sustainability and efficiency
4. step by step growth of digital governance platforms

Still, every example brings up issues like privacy concerns, ongoing expenses, and reliance on tech. Whether artificial intelligence works well in city design isn't just about tools - it ties back to rules, faith in systems, and human judgment.

6. Advantages and Challenges of AI in Urban Planning

Cities might work better when artificial intelligence plays a role in planning. Yet problems pop up - some tied to code, others rooted in how people feel about change.

What helps? Seeing what AI can do alongside what it cannot. That balance shapes smarter, fairer urban designs down the road.

6.1 Advantages of AI in Urban Planning

What makes AI useful is how well it handles massive, tangled datasets. Cities today flood systems with information - sensors, phones, traffic logs, government files never stopped before. Old-style planning usually stumbles when faced with that flood. Using machines to learn from data helps spot what goes unnoticed at once. When information flows fast through systems built for that job, hidden shapes begin to show up clearly. People who plan gain sharper insight because of it. Decisions get better when they rely on what the numbers actually say.

One of the key benefit is predictive insights. Urban expansion, road congestion, power usage - even nature's balance - can be forecast using artificial intelligence. By seeing what might come, officials prepare for challenges ahead. Prevention takes shape before crisis does. Take traffic forecasts powered by artificial intelligence - these could guide changes to city layouts while shifting bus routes ahead of gridlock spikes.

Cities now rely on smarter infrastructure thanks to artificial intelligence. Energy grids adjust in real time, while water networks and trash pickup learn from data patterns. Predictive checks keep systems running longer without breakdowns.

Efficiency grows quietly, cutting expenses while boosting trust in public services. Environmental harm shrinks as a result across urban cores. On top of that, artificial intelligence backs up real-world planning scenarios. Through testing various growth paths, software models let professionals explore how each choice might play out. Less unknown factors creep in when predicting outcomes becomes clearer. As a result, working versions of better ways forward stand out more easily. Using digital twins helps too - these virtual setups let teams try out plans without causing harm later. Testing happens inside simulated spaces ahead of actual deployment.

A key advantage is stronger public involvement. Tools powered by artificial intelligence turn planning data into clear, dynamic visuals - easier to share with community members. These interfaces help people see what new developments might look like, spot differences between options, then join conversations around decisions in real ways. What stands out is how decisions become clearer and involve more people in city management.

6.2 Challenges and Limitations

Even with benefits, putting AI into city design isn't without hurdles. A major concern? Not enough good data. Machines need lots of correct, current details to work. That kind of input often falls short. When data feels old, misses key points, or shows one-sided views, model outcomes might miss the mark - this messes with strategy down the line. In certain urban areas - particularly those still building tech foundations - weak digital backbone weakens what artificial intelligence can do.

Security around personal data stands out as a top issue. City tech platforms depend on ongoing tracking of how people move, travel, and use energy. If rules stay weak, private details could be put at risk. That kind of information opens doors to unwanted watching plus digital threats.

One issue lies in algorithmic bias. Learning happens through data, often shaped by past social patterns or outdated designs. When these backgrounds are baked into training sets, outcomes can tilt without warning. Systems might sort neighborhoods unevenly. Services could appear out of reach for certain groups. Decisions may reflect hidden slants instead of fairness. Fixing these problems means picking good data, keeping algorithms clear, while people always watch them.

What worries people too is how much cities lean on tech. If smart systems break down or stop working, places that depend on them could struggle. Even more, when new versions arrive, older ones might need costly updates just to keep running. Building and keeping up with AI tools takes big money and skilled workers. Not every town has that kind of support behind it.

What happens next depends heavily on who makes choices behind closed systems.

Automated tools now shape how cities unfold, yet answers about their effects stay out of reach. When complex software drives decisions, tracking cause and effect grows messy over time. Without clear oversight, mistakes in city design might stick around longer than expected. Decisions once visible now

hide inside layers few can touch. Accountability slips when processes become too automatic. Outcomes matter less if nobody knows why they occurred. Hidden logic quietly reshapes public spaces without public input. Without transparency, errors in city planning could last longer than expected. So, AI might help instead of taking over when people plan and make choices together. It serves better when used to assist, not erase, human roles in governance.

7. Future Prospects of AI in Urban Planning

City planning with artificial intelligence depends on growth within digital systems, computing tools, and connected data networks. When cities link up more tightly using internet-connected devices, fast wireless tech, and online storage platforms, they will gather far more varied and extensive information. Because of this shift, smart software will handle complex tasks with greater accuracy while making choices swiftly in real moments.

A fresh path opens with the growth of all-in-one urban digital twins. Right now, most digital systems target single areas like traffic or power grids. Later on, they'll weave together nature, people, money, and space details into one shared network. These smart twins powered by artificial intelligence could test how cities might grow, check weather toughness plans, then fine-tune public works spending - better, slower, stronger. These setups could help shape city plans that shift and grow, guided by live information.

A different key trend involves city planning adjusted for climate shifts. Because global warming grows stronger, urban areas face hotter temperatures, intense storms, and limited resources. Machines learning patterns help forecast weather patterns across entire cities, giving designers sharper tools. They might shape parks smarter, plant trees where they count, and cut pollution output without traditional fixes. One day, artificial intelligence could help pick what buildings are made of. It might also figure out how packed city areas should be while cutting down energy waste. Instead of guessing, it learns patterns to make whole neighborhoods run smoother.

Now imagine design systems talking to each other in ways they never did before. When structure data meets energy outputs, machines begin shaping cities nobody saw coming. Instead of sticking to old layouts, algorithms mix traffic patterns with climate needs on the fly. This shift opens doors where rules bend without losing safety or efficiency. Cities grow not from templates but from patterns hidden inside numbers that adapt fast.

When it comes to decision making, new tools using artificial intelligence might help people take a more active role in shaping cities. Instead of just observing change, residents could explore different futures through dynamic displays or live-like visuals. These systems would let individuals interact closely with ideas about how neighborhoods might evolve. By processing comments from locals, smart algorithms may uncover what matters most to communities. Trends that were once hard to notice might become clearer over time through such automated insights. A shift like this might help shape choices that feel fairer, less exclusive.

Still, cities using more AI need clearer rules and moral guidelines. When algorithm-driven designs start reshaping neighborhoods, openness, responsibility, and safe data handling should come first. Global consistency plus teamwork across fields might make sure tech progress doesn't ignore fairness or nature's balance.

What happens next with AI in city design doesn't just come from better tools - it also hinges on how strong institutions are, along with whether people believe in them. Places that build skills in tech, support transparent data sharing, and apply ethics into decisions tend to make smarter use of smart algorithms.

8. Conclusion

Looking back, the study focused on how artificial intelligence supports city planning using data, especially in smart city settings. With cities becoming more intricate, old methods often fail when dealing with shifting demands around transportation, zoning, resources, and nature care. Tools powered by AI help professionals analyze vast amounts of information quickly, explore what might come next, while adjusting city functions on the fly.

From roads to rain sensors, change hums beneath everyday systems. Think of how Singapore handles traffic - not by guesswork but patterns learned from smart signals. In Barcelona, planners lean on crowd patterns shaped by open tools anyone can tweak. Helsinki goes further, feeding green spaces into city grids where trees compete with traffic stats for attention. Each place runs on invisible threads pulled by machines that process what humans once calculated by hand. Watch closely: sidewalks adapt to phone data, parks respond to air quality logs, bridges learn stress levels from weight records. This isn't

tomorrow - it's now reshaping decisions grounded not in hunches but patterns stored across servers humming under streets.

Still, the study points out major hurdles - poor data accuracy, personal privacy risks, built-in algorithm flaws, reliance on tech systems, and management problems. Because of these issues, people must stay involved in overseeing how AI helps plan cities, ensuring ethical choices remain part of the process. Instead of taking over from city designers, artificial intelligence could act as a tool to guide decisions, strengthening what experts already know and how they think ahead.

City planning might lean heavily on digital replicas by 2025, using artificial intelligence to forecast heat waves and storm surges. Instead of traditional blueprints, designers could rely on algorithms that reshape streets and towers on the fly. Decision making at the neighborhood level may shift toward online forums where residents help shape rules through shared discussions. When guided carefully, these tools could balance traffic flow, green spaces, and fair access to resources across districts.

Still, Artificial Intelligence shapes how smart cities are changing - though it brings both power and confusion. For it to work well, cities must weigh machine learning against real human needs, rules that apply, and teamwork across different fields. When tech advances match long-term city goals, places might grow into livelier, sharper, fairer spaces.

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INNOVATION DEVELOPMENT IN ALBANIA: CHALLENGES, ADOPTION PATTERNS, AND POLICY PERSPECTIVES

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Abstract

Innovation represents a fundamental driver of economic growth, competitiveness, and sustainable development, particularly in transition economies. Albania, as a developing country with a strong agricultural profile, faces structural, institutional, and technological challenges that influence innovation performance and adoption rates. This paper analyses the current state of innovation in Albania, focusing on adoption trends, digitalisation processes and innovation performance indicators. The study applies a qualitative and analytical review approach supported by empirical data and international comparative literature. Findings indicate moderate progress in innovation adoption, particularly among enterprises, while agricultural innovation and digital transformation remain limited due to fragmented farm structures, low investment in research and development, and institutional constraints. The study highlights the importance of strengthening innovation systems, improving policy frameworks, and enhancing collaboration between academia, industry, and rural communities. The results contribute to the discussion on innovation-driven rural development and provide policy recommendations for strengthening Albania's innovation ecosystem.

Keywords: innovation adoption, digital agriculture, innovation systems, Albania, rural development

1. Introduction

Innovation is widely recognized as a central factor influencing economic development, productivity growth and sustainable competitiveness across sectors. According to the Organisation for Economic Co-operation and Development (OECD), innovation includes the implementation of new or significantly improved products, processes, marketing methods or organisational practices (OECD, 2018). Innovation is particularly relevant in agriculture and rural development, where technological progress and knowledge transfer contribute to improved productivity, resource efficiency and environmental sustainability (FAO, 2018).

Innovation development in Albania faces significant challenges and unique adoption patterns influenced by various socio-economic and regulatory factors. As Albania seeks to bolster its innovation landscape, it is important to examine the challenges, adoption dynamics, and the associated policy perspectives that shape the development of innovation.

Albania's innovation sector is constrained by several factors, notably regulatory barriers, infrastructural deficits, and cultural attitudes towards innovation. A study on renewable energy highlights the complexity of navigating regulatory barriers that often stifle innovative capacity (Oduro et al., 2024). Such barriers include outdated policies and conflicting regulations, which are prevalent in many sectors, including technology and energy. The absence of a cohesive legal framework can inhibit investment and limit the potential for technological advancement (Nwokolo et al., 2024; Igbinenikaro & Adewusi, 2024).

Furthermore, the transition to a digital economy, as noted by Hoxhaj and Halilaj, illustrates the pressing need for reforms in digital governance to align with European Union standards (Hoxhaj & Halilaj, 2025). The authors argue that while Albania's digital transformation is progressing, legal and policy challenges related to e-governance, cybersecurity, and digital inclusion significantly impact innovation diffusion. The deployment of social media within the agricultural sector facilitates significant advancements in communication, knowledge dissemination, and community engagement. By connecting farmers to resources and to each other, social media supports the modernization of agricultural practices and enhances the potential for collaborative, sustainable development within rural territories. (Minga, A. et al., 2025).

The adoption of innovative solutions in Albania may reflect a cautious yet gradual process, influenced by various external and internal factors. Drawing from case studies of agricultural innovation, Salavisa et al. suggest that social and institutional innovation plays a critical role in the adoption of new technologies, particularly in sectors like agribusiness (Salavisa et al., 2021). The study identifies key factors such as supportive policy measures and networked collaborations among producers that positively influence the diffusion of innovations.

Nevertheless, the complexities of adopting new technologies are compounded by the lack of adequate technology dissemination strategies highlighted in the context of renewable energy (Nwokolo et al., 2024). This illustrates a broader theme within Albanian society where innovative practices encounter resistance due to ingrained cultural attitudes towards risk and change.

To foster an environment conducive to innovation, Albania's policymakers need to adopt a multi-faceted approach that encompasses regulatory reform, investment in education, and the establishment of supportive infrastructure. The successful implementation of regulatory reforms is crucial for addressing the identified barriers to innovation. For instance, global perspectives on FinTech suggest that comprehensive regulatory frameworks are essential to balance consumer protection and operational flexibility (Xu & Da-wei, 2020; Igbinenikaro & Adewusi, 2024).

Additionally, drawing from innovative practices observed in other regions, it is evident that establishing regional support structures can enhance innovation processes. Hofman and Bruijn emphasize the importance of aligning regional support mechanisms with the needs identified within firms, which can facilitate a smoother transition towards innovation adoption (Hofman & Bruijn, 2010). Policymaking that incorporates stakeholder engagement and feedback mechanisms can help tailor strategies that are responsive to the local context.

Developing economies often face structural barriers that limit innovation adoption, including insufficient institutional support, limited financial resources and weak knowledge transfer mechanisms. Albania reflects many of these characteristics, as its economic structure is strongly influenced by small-scale agricultural production, limited technological integration and moderate investment in research and development activities. Studies emphasise that small farm structures and fragmented land ownership significantly influence the adoption of innovative technologies and practices (Diao et al., 2023).

International reports such as the European Innovation Scoreboard highlight disparities in innovation performance among European countries, particularly between EU members and candidate or transition economies. Albania continues to demonstrate relatively low innovation performance compared with European standards, indicating the need for improved policy coordination, investment strategies, and institutional capacity building (European Commission, 2023).

Innovation development in Albania is significantly shaped by its unique challenges, adoption patterns, and policy frameworks. Addressing regulatory hurdles, fostering a more conducive innovation culture, and reforming existing policies while learning from international experiences can pave the way for sustainable innovation growth in Albania. By recognizing these interconnected domains, Albania can enhance its innovation landscape and align with broader European and global standards.

The purpose of this study is to analyse innovation development in Albania, with particular emphasis on adoption trends, digital transformation processes and structural barriers affecting innovation performance. The study aims to contribute to the academic and policy debate on innovation-driven development in transition economies.

2. Methodology

This research applies a qualitative analytical approach based on literature review and secondary data analysis. The study combines theoretical perspectives on innovation systems with empirical data related to innovation adoption and performance indicators in Albania.

The literature review includes international academic publications, institutional reports and policy documents related to innovation systems, digital agriculture and innovation adoption models. Sources include OECD innovation frameworks, FAO agricultural innovation studies and European Commission innovation performance reports.

The methodological approach follows a comparative analytical framework that examines innovation performance indicators, including enterprise innovation activity, digitalisation levels and agricultural innovation adoption patterns. The research integrates theoretical frameworks such as the Agricultural Innovation Systems (AIS) model, which emphasises interactions among stakeholders, including research institutions, government agencies, private enterprises and rural communities (World Bank, 2012).

Secondary data analysis is used to evaluate innovation activity trends in Albania, focusing on enterprise innovation rates, financial support mechanisms and technological adoption levels. The study also evaluates structural and institutional barriers influencing innovation performance, including governance structures, financial accessibility and knowledge transfer limitations.

3. Results and Discussion

3.1 Innovation Adoption Trends in Albania

The analysis indicates a gradual improvement in innovation activity among Albanian enterprises. Recent data show that approximately 42.9% of enterprises engaged in at least one innovation activity

during the 2020–2022 period, demonstrating increased innovation engagement compared with previous years

Enterprises engaged in innovation activities show improved employment growth and increased net sales, confirming international findings that innovation contributes directly to economic productivity and competitiveness (OECD, 2018). However, research and development investment remains limited, with only a small percentage of innovative enterprises receiving public financial support or fiscal incentives.

Comparative analysis using European Innovation Scoreboard indicators demonstrates that Albania remains classified among moderate or emerging innovators, reflecting gaps in research infrastructure, digital skills development and institutional innovation capacity (European Commission, 2023).

3.2 Digitalisation and Agricultural Innovation

Digital transformation represents a critical dimension of innovation development. Digital technologies such as precision agriculture, data management systems, and smart irrigation techniques have demonstrated significant productivity and sustainability benefits globally (FAO, 2018).

Despite the lack of technological infrastructure in some areas, the interest of young people in pursuing careers in the fields of multimedia and digitalization is high, signaling the need for modernization of curricula, expansion of practical opportunities, and the establishment of special laboratories in universities and schools in non-urban areas. (Minga, A. et al., 2025).

However, the adoption of digital agricultural technologies in Albania remains relatively low. Structural characteristics such as fragmented farm ownership, limited financial access, and insufficient extension services limit technological diffusion. Small-scale farmers often face high investment costs and limited access to knowledge transfer networks, which reduces innovation adoption capacity.

International literature emphasizes that effective agricultural innovation requires integrated knowledge systems and collaborative platforms connecting farmers, research institutions and policy-makers (World Bank, 2012). The absence of fully developed Agricultural Innovation Systems remains a key barrier in Albania.

3.3 Institutional and Policy Barriers

Innovation development is strongly influenced by policy frameworks and institutional governance. Albania demonstrates progress in establishing innovation-supporting institutions and strategies; however, coordination among stakeholders remains limited. Public funding for research, extension services and innovation programmes is relatively low compared with European benchmarks.

Studies indicate that successful innovation systems depend on strong institutional networks, financial incentives, and collaborative governance models. The limited participation of enterprises in innovation funding schemes suggests the need for improved policy implementation and increased accessibility of financial instruments.

3.4 Social Innovation and Rural Development

Social innovation represents an important dimension of rural development, particularly in transition economies. Social farming and community-based innovation models contribute to employment generation, social inclusion and sustainable resource management.

International experiences demonstrate that social innovation strengthens rural resilience and improves community participation in development processes (Baglioni & Sinclair, 2018). Albania shows emerging examples of social innovation, but scaling and institutional support remain limited. Territorial innovation systems include mutually connected enterprises in certain sectors, appropriate suppliers, and the service sector, as well as a series of supporting institutions. (Minga, A. et al., 2023).

4. Conclusions

Innovation development in Albania demonstrates gradual progress but remains constrained by structural, financial, and institutional challenges. Enterprise innovation activity has increased, indicating growing awareness and capacity for innovation-driven growth. However, agricultural innovation and digital transformation remain limited due to fragmented production structures and insufficient knowledge transfer mechanisms.

The study confirms that strengthening national innovation systems is essential for improving innovation adoption and competitiveness. Policy interventions should prioritise investment in research and development, digital infrastructure, and capacity-building programmes for farmers and enterprises.

Furthermore, enhancing collaboration among universities, industry, and rural communities is critical for promoting innovation ecosystems. Social innovation models should be integrated into rural development strategies to improve inclusiveness and sustainability.

Future research should focus on empirical evaluation of innovation adoption models and the role of digital transformation in supporting sustainable rural development in transition economies.

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Historical sciences

ZOOMORPHIC REPRESENTATIONS OF EVEN-TOED UNGULATES ON GLAZED CERAMICS OF THE SELJUK PERIOD IN AZERBAIJAN

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ЗООМОРФНЫЕ ИЗОБРАЖЕНИЯ ПАРНОКОПЫТНЫХ НА ГЛАЗУРОВАННОЙ КЕРАМИКЕ СЕЛЬДЖУКСКОГО ПЕРИОДА В АЗЕРБАЙДЖАНЕ

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Abstract

The article examines a group of glazed ceramics from the Seljuk period (12th – early 13th centuries), decorated with representations of even-toed ungulates (gazelles, antelopes, and rams), originating from archaeological contexts in Azerbaijan. The study is based on morphological, technical-technological, comparative-typological, and iconographic methods. Particular attention is paid to the characteristics of the underglaze painting technique, the methods of sgraffito engraving on slip, and the stable stylistic features of the zoomorphic imagery. It has been established that the images of even-toed ungulates constitute not a random decorative element, but a consistent iconographic formula rooted in the artistic canon characteristic of the Seljuk period. The examined group of ceramics is interpreted as a product of urban craft workshops oriented toward prestigious consumption and as an important source for the study of the artistic, cultural, and symbolic representations of medieval Azerbaijan.

Аннотация

В статье рассматривается группа глазурованной керамики сельджукского периода (XII – начало XIII вв.), украшенной изображениями парнокопытных животных (газелей, антилоп, баранов), происходящая из археологических комплексов Азербайджана. Исследование опирается на морфологический, технико-технологический, сравнительно-типологический и иконографический методы. Особое внимание уделяется характеристике технологии подглазурной росписи, приёмам гравировки по ангобу и устойчивым стилистическим особенностям зооморфных изображений. Установлено, что образы парнокопытных животных представляют собой не случайный декоративный элемент, а устойчивую иконографическую формулу, укоренённую в художественном каноне характерным для сельджукского периода. Рассматриваемая группа керамики интерпретируется как продукт городских ремесленных мастерских, ориентированных на престижное потребление, и как важный источник для изучения художественных, культурных и символических представлений средневекового Азербайджана.

Keywords: glazed ceramics; Azerbaijan; zoomorphic representations; even-toed ungulates; underglaze painting; artistic traditions of the Seljuk world.

Ключевые слова: глазурованная керамика; Азербайджан; зооморфные изображения; парнокопытные животные; подглазурная роспись; художественные традиции сельджукского мира.

В контексте изучения материальной культуры сельджукского периода в Азербайджане (XII – начало XIII вв.) глазурованная керамика с полихромной под глазурной росписью занимает особое место как индикатор высокого уровня технологического развития, интенсивных торгово-культурных контактов и сформировавшихся эстетических представлений эпохи. В рамках этого обширного комплекса особый интерес представляет группа сосудов с зооморфными изображениями, являющаяся одним из наиболее сложных для интерпретации пластов археологического материала и находящаяся на стыке ремесленной практики, художественного канона и символических представлений средневекового общества (7). В научной литературе вопросы зооморфной иконографии в искусстве Ближнего Востока и сопредельных регионов традиционно рассматривались преимущественно на материале торевтики, текстиля и монументального искусства доисламского и раннеисламского времени. Изображения животных на металлических сосудах и предметах парадного назначения подчинялись устойчивым иконографическим схемам и выполняли не столько повествовательную, сколько репрезентативную и символическую функцию (12). В дальнейшем О. Грабар, анализируя трансформацию художественных традиций в условиях исламской культуры, подчеркнул преемственность визуальных форм и иконографических моделей, восходящих к доисламскому искусству, при их адаптации к новым эстетическим и культурным контекстам (10). При этом образы реальных животных, в частности парнокопытных — газелей, антилоп, баранов и козлов, — несмотря на их широкое распространение в прикладном искусстве средневекового Востока, значительно реже становились предметом специального анализа, особенно применительно к керамическим комплексам Азербайджана сельджукского времени. Между тем именно эта категория изображений, лишённая прямой мифологической напряжённости и связанная с устойчивыми художественными формулами, заимствованными из торевтики и других видов изобразительного искусства, представляет собой ценный источник для изучения локальных особенностей декора и глубинных пластов анималистической символики в условиях исламизированного общества (3). Настоящее исследование основывается на анализе корпуса археологических находок, происходящих из стратифицированных раскопок ключевых городских центров Азербайджана сельджукского периода.

Целью статьи является технико-технологическая и иконографическая характеристика группы глазурованной керамики с изображениями парнокопытных как особого феномена в рамках сельджукской эпохи керамического производства Азербайджана. Для реализации этой цели последовательно решаются следующие **задачи: введение в научный оборот и формализованное описание** конкретных артефактов с фиксацией всех существенных параметров: состав ангоба и глазури, палитра пигментов, техника нанесения рисунка (гравировка, линейная графика). Проведена реконструкция технологической цепочки на основе следов производства, сохранившихся на предметах. Особое внимание уделяется приемам, обеспечивающим высокую детализацию изображения (качество гравировки по ангобу, контроль над растеканием глазури). Имеется иконографический и стилистический анализ изображений. Проанализированы принципы композиции, в частности, взаимодействие фигуры животного с фоновым орнаментом (растительным ислими, геометрическим).

Впервые предметом специального рассмотрения становится не «зооморфная керамика» вообще, а ее конкретная, четко очерченная подгруппа. На основе конкретного, верифицируемого археологического материала (включая ранее не публиковавшиеся или малоизвестные фрагменты) формулируются признаки, позволяющие идентифицировать данную группу. Предлагается взгляд на эти изображения не просто как на «украшение», а как на устойчивый элемент художественного языка, требующий семантической расшифровки.



Рис. 1

Рассмотрим артефакт, обнаруженный в ходе раскопок на территории древней Гянджи в 1938 г, который является характерным образцом высококачественной глазурованной (поливной) керамики, производившейся в городских ремесленных центрах Азербайджана в XII–XIII вв (рис. 1). Техничко-технологический анализ позволяет реконструировать стандартную для эпохи сложную цепочку производства. Изделие прошло качественный обжиг, в результате которого мелкодисперсная глина приобрела твердость и характерный светло-оранжевый (розоватый) цвет, типичный для многих мастерских региона. Внутренняя поверхность была покрыта тонким слоем ангоба (жидкой глины светлого тона), создавшего идеальный белый фон для росписи. Основной рисунок – изображение фантастического животного – был нанесен методом гравировки (процарапывания) по сырому ангобу с последующей подглазурной росписью коричневым пигментом на основе оксидов железа. Дополнительные растительные орнаменты в стиле ислими, исполнены зеленой глазурью, цвет которой достигался за счет соединений меди. После росписи предмет был покрыт прозрачной поливой (свинцовой или щелочной глазурью) и подвергнут повторному обжигу при более низкой температуре, в результате чего глазурь затвердела, зафиксировав рисунок и придав поверхности блеск (4). Несмотря на неполную сохранность фрагмента, выявляется ряд важных стилистических черт. Центральным элементом декора является парнокопытное животное, вероятно антилопа. Это указывает на распространенность в регионе обще-сельджукских художественных канонов. Фигура представлена в **правом профильном ракурсе**, что является абсолютной нормой для искусства того времени. **Динамичная поза** (вытянутая шея, согнутые в движении передние ноги, штриховка на туловище, имитирующая мускулатуру или шерсть) свидетельствует о высоком мастерстве резчика и понимании анималистической пластики (4). Это изображение заключено в рамку из стилизованных растительных мотивов ислими, что является классическим композиционным приемом, отделяющим основное изображение от фона и заполняющим свободное пространство.

Обнаружение данного фрагмента в Гяндже – одном из столичных городов эпохи – подтверждает статус полихромной глазурованной керамики как престижного продукта, доступного состоятельной городской элите (1). Сочетание сложной техники (гравировка по ангобу), полихромной палитры и изощренного иконографического сюжета позволяет отнести этот артефакт к числу **высокохудожественных произведений** прикладного искусства. Его изучение вносит вклад в понимание уровня развития ремесла, эстетических предпочтений и характера культурных связей Азербайджана в составе обширного сельджукского мира (5).



Рис.2

Интерес представляет фрагмент стенки парадного глазурованного сосуда с иконографическим зооморфным изображением. (рис.2) Вероятно это фрагмент крупной миски или блюда открытой формы; реконструкция кривизны стенки допускает также принадлежность к иному открытому сосуду значительного диаметра. Место находки — городище Древняя Гянджа на территории современного Азербайджана. Предмет обнаружен в 1940 г. в ходе археологических работ. Хронологически артефакт относится ко второй половине XII — первой половине XIII вв., периоду развитого средневековья, когда регион находился в сфере сельджукского и хорезмийского политического и культурного влияния (1). Фрагмент представляет собой часть стенки сосуда, изготовленного из хорошо отмученной глиняной массы с плотным, равномерно обожжённым черепком. Наружная поверхность покрыта ровным слоем светло-оранжевой свинцовой глазури. Внутренняя, лицевая поверхность тщательно заглажена и покрыта прозрачной либо светло-зелёной глазурью, служащей фоном для подглазурной росписи. В центральной зоне сохранившегося фрагмента методом линейно-графической росписи оксидами металлов, предположительно марганцевыми пигментами, выполнено стилизованное изображение парнокопытного животного, интерпретируемого как джейран (газель), представленное в правом профильном ракурсе (4). Сохранились значительные части туловища, головы и шеи животного. Голова вытянутой формы, с мягким и плавным контуром; глаз передан в виде крупного концентрического круга, что является характерным стилистическим приёмом сельджукской зооморфной иконографии. Ушные раковины не выделены и, вероятно, намеренно слиты с контуром головы в рамках принятой декоративной стилизации. Туловище животного моделировано обобщённо, плавными и уверенными контурными линиями, передающими стройные пропорции фигуры. В области плечевого пояса и рёбер включён растительный орнамент в виде стилизованных побегов или листьев (4). Сочетание зооморфного образа с растительными мотивами является устойчивым композиционным приёмом в искусстве Ближнего Востока и Средней Азии и может интерпретироваться как отсылка к природной среде обитания животного и к поэтико-символическому образу сада (5). Конечности переданы условно: сохранилось изображение лишь одной передней ноги, направленной вперёд; подобная редукция второстепенных деталей при профильном изображении соответствует принципам плоскостной декоративной композиции, характерной для средневековой исламской живописи и керамики. Верхняя часть головы с рогами, а также задняя часть туловища с хвостом утрачены. Стилистически изображение отличается лаконичностью, чёткостью и уверенностью контурного рисунка, рациональным заполнением

декоративного поля и отсутствием стремления к натуралистической детализации. Трактовка образа сочетает узнаваемые видовые признаки, такие как стройный профиль и характерный изгиб шеи и головы, с декоративной условностью отдельных элементов, прежде всего глаза и орнаментального дополнения (6). Подобная манера характерна для подглазурной расписной керамики сельджукского времени и свидетельствует о работе опытного мастера, знакомого с устойчивыми иконографическими канонами эпохи. В иконографическом отношении изображение джейрана в светском искусстве исламского мира устойчиво связано с представлениями о красоте, грации и быстроте, а также с мотивами охоты и поэтическим образом сада. В контексте парадной столовой керамики подобные зооморфные сюжеты выполняли преимущественно декоративно-символическую функцию и отражали вкусы городской и придворной среды (5). Технология изготовления сосуда включала формовку на гончарном круге, первичный бисквитный обжиг, нанесение светлой глазурной основы на внутреннюю поверхность, подглазурную роспись оксидными пигментами с использованием кисти или калама и последующий вторичный обжиг при температуре порядка 800–900 °С для закрепления глазури и росписи. Сохранившаяся высота фрагмента составляет 3–3,5 см, максимальная длина и ширина — около 12 см. Реконструируемый по кривизне стенки диаметр сосуда составляет приблизительно 7,8 см, что указывает на относительно крупный открытый сосуд. Сохранность предмета фрагментарная: утрачены верхний край сосуда, задняя часть фигуры животного, верх головы с рогами и, вероятно, дополнительные элементы орнаментальной композиции. Повреждения глазурного слоя незначительны, роспись в целом хорошо читается (4). Рассматриваемый фрагмент представляет собой характерный образец парадной глазурованной керамики Гянджи XII–XIII вв.

Артефакт свидетельствует о распространённости в Гяндже развитых зооморфных сюжетов, выполненных в обще-сельджукской стилистической манере, и подчёркивает включённость города в широкий культурно-художественный обмен средневекового исламского мира. Перспективным направлением дальнейших исследований представляется проведение расширенного сравнительно-иконаграфического анализа с материалами из других центров Азербайджана, а также Ирана и Средней Азии, и технико-технологическое изучение состава глазури и пигментов.



Рис.3

Рассмотрим фрагмент глазурованной керамики с иконографическим изображением джейрана. (рис.3) Фрагмент глазурованного керамического сосуда происходит с территории городища Древняя Гянджа и был обнаружен в 1939 г. Этот фрагмент представляет собой часть стенки парадного сосуда, изготовленного из хорошо отмученной глины и покрытого светло-коричневой свинцовой глазурью. Черепок плотный, равномерно обожжённый. Внутренняя поверхность сосуда предварительно ангобирована и служит фоном для подглазурной росписи, выполненной в технике линейно-графического рисунка. Декоративная композиция включает стилизованное изображение парнокопытного животного, вероятно, джейрана или близкого к нему вида, выполненное тёмно-коричневым контуром. Животное представлено в профильном

ракурсе; особое внимание уделено изображению конечностей, число которых подчеркнуто и визуально акцентировано, что позволило исследователю интерпретировать фигуру как движущуюся. Линии контура уверенные, чёткие, что свидетельствует о профессиональном уровне исполнения. Вокруг зооморфного изображения размещены элементы растительного орнамента, выполненные зелёной краской, а также геометрические мотивы в виде ромбов и групп из трёх точек, характерных для декоративного языка сельджукской керамики. Композиция отличается уравновешенностью и рациональным распределением элементов в пределах декоративного (4). Сочетание зооморфного мотива с растительными и геометрическими элементами указывает на принадлежность изделия к светской художественной традиции, распространённой в средневековом исламском искусстве и особенно характерной для подглазурной расписной керамики XII–XIII вв.(2). Технология изготовления сосуда включала формовку на гончарном круге, первичный обжиг, нанесение ангоба, подглазурную роспись оксидными пигментами, глазурование и последующий вторичный обжиг. Размеры фрагмента составляют около 14 см в длину и 9 см в ширину, что позволяет предполагать его принадлежность к сравнительно крупному открытому сосуду, вероятно, предназначенному для парадного или столового использования. В целом данный фрагмент представляет собой характерный образец высококачественной глазурованной керамики Гянджи развитого средневековья и иллюстрирует распространённость зооморфных мотивов в декоративном репертуаре местных гончарных мастерских. Он подтверждает тесные художественные связи Гянджи с обще-сельджукским культурным пространством и высокий уровень развития изобразительных традиций в городском ремесленном производстве XII–XIII вв (8).

В сельджукском искусстве, особенно в керамике, часто можно встретить изображение парнокопытных животных, таких как антилопы, олени в зависимости от региона. Сравнительно-типологический метод в данном случае опирается на корпус опубликованных аналогий по сельджукской керамике и позволяет уверенно атрибутировать и датировать рассматриваемый фрагмент. В работе Э. Грубе посвящённой сельджукской керамике, выделяется группа подглазурной расписной посуды, характеризующейся использованием ангоба, прозрачной глазури и уверенной контурной линии. Для этой группы типичны зооморфные изображения, вписанные в орнаментальное поле (11). Типологически это столовая расписная керамика городского круга, не связанная с культовой или архитектурной функцией. Анализируя исламское искусство в межрегиональной перспективе, можно сделать вывод об устойчивости зооморфных мотивов как художественных схем, сохраняющихся на протяжении длительного времени и в разных регионах исламского мира (11). Надо отметить, что образ антилопы предстает не частным случаем, а репрезентацией устойчивой иконографической формулы — «бегущего травоядного», особенно популярной в светском искусстве Азербайджана сельджукского времени (6).

Проведённый анализ зооморфной глазурованной керамики с изображениями парнокопытных животных позволяет рассматривать данную группу памятников как самостоятельный и устойчивый компонент художественного репертуара сельджукского периода в Азербайджане. Археологические материалы из Гянджи демонстрируют единые технико-технологические приёмы, общность стилистических решений и устойчивость иконографических схем, что свидетельствует о включенности местных гончарных мастерских в широкое общесельджукское культурное пространство (9). Изображения газелей и антилоп, выполненные в профильном ракурсе и сочетающиеся с растительным и геометрическим орнаментом, отражают не натуралистическое стремление к передаче конкретного вида, а использование типизированного образа «движущегося травоядного», характерного для светского искусства исламского мира XII–XIII вв. Их семантика, вероятно, была связана с представлениями о красоте, жизненной энергии, природной гармонии и охотничьей культуре, что делало подобные мотивы особенно уместными в декоре парадной столовой посуды (6). Таким образом, зооморфные изображения парнокопытных на глазурованной керамике следует интерпретировать не как второстепенное украшение, а как значимый визуальный элемент, отражающий художественные вкусы городской элиты и устойчивые символические представления эпохи. Дальнейшие исследования, включая химико-технологический анализ глазури и расширенное межрегиональное сравнение, способны существенно углубить понимание путей распространения и трансформации данных образов в рамках сельджукского художественного мира.

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Medical sciences

DIABETES MELLITUS AS A CHALLENGE OF THE 21ST CENTURY: MODERN APPROACHES TO DIAGNOSIS, TREATMENT, AND PREVENTION

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Abstract

Diabetes mellitus is one of the most common chronic diseases of our time, characterized by complex carbohydrate metabolism disorders and systemic damage to various organs and tissues. With rapid urbanization, changing diets, and declining physical activity, this condition has become a global medical and social problem. The disease is characterized by a long, often asymptomatic course in its early stages, which complicates timely diagnosis and contributes to the development of severe vascular and metabolic complications.

This article systematizes current understanding of the pathogenesis of diabetes mellitus, highlighting the role of insulin deficiency and insulin resistance in the development of chronic hyperglycemia. The article examines the main clinical manifestations, laboratory diagnostic criteria, and principles for differentiating between various types of the disease. Particular attention is paid to a comprehensive approach to treatment, including lifestyle modification, non-drug methods for correcting metabolic disorders, modern pharmacological agents, and insulin therapy. The role of self-monitoring as a key factor in achieving sustainable disease management and preventing complications is analyzed separately.

The study also explores the mechanisms underlying micro- and macrovascular complications, which determine patients' prognosis and quality of life. It demonstrates that effective glycemic control, early identification of risk factors, and active patient participation in treatment are the foundation for successful disease management. It concludes that modern diabetology requires a stronger focus on prevention and the development of personalized treatment approaches that make diabetes a manageable condition with timely and comprehensive medical support.

Keywords: hyperglycemia, diagnostics, insulin resistance, prevention, diabetes mellitus.

Introduction: *In the 21st century, diabetes mellitus has ceased to be viewed solely as a medical problem and has become a global socioeconomic challenge. The rapid increase in incidence worldwide is driven by a combination of factors, including urbanization, changing diets, decreased physical activity, and increasing life expectancy. According to international studies, the prevalence of the disease continues to rise steadily, placing a significant burden on healthcare systems and requiring a revision of prevention strategies, early diagnosis, and long-term patient management.*

The systemic nature of diabetes mellitus makes this problem particularly pressing. Chronic hyperglycemia damages the blood vessels, nervous system, and vital organs, significantly increasing the risk of disability and premature death. Moreover, the disease can remain asymptomatic for long periods, with clinical manifestations often appearing only when complications develop. Therefore, early diagnosis, timely initiation of treatment, and the development of self-management skills and a responsible attitude toward treatment are crucial.

Modern diabetology is characterized by significant advances in understanding the pathogenetic mechanisms of the disease and expanding therapeutic options. The development of new pharmacological agents with not only hypoglycemic but also cardio- and nephroprotective effects, the introduction of continuous glucose monitoring technologies, and personalized treatment regimens have significantly improved the effectiveness of disease management. However, successful diabetes management is impossible without a comprehensive approach, including lifestyle modification, patient education programs, and risk factor prevention.

The purpose of this article is to systematize current understanding of diabetes mellitus as a complex metabolic disease, including its pathogenesis, clinical manifestations, diagnostic methods, treatment principles, self-monitoring, and complication prevention. A comprehensive analysis of these aspects allows us to view diabetes mellitus not only as a chronic pathology but also as a manageable condition in which timely medical and behavioral interventions can ensure a high quality of life and prolong life for patients.

Diabetes mellitus is a heterogeneous group of metabolic diseases united by a common pathophysiological feature: chronic hyperglycemia, which occurs due to impaired insulin secretion, its action, or a combination of these mechanisms. Under physiological conditions, insulin, synthesized by the β -cells of the pancreas, ensures the transport of glucose into cells and regulates carbohydrate, fat, and protein metabolism. In type 1 diabetes mellitus, absolute insulin deficiency develops due to the autoimmune destruction of β -cells, while type 2 diabetes mellitus is characterized by insulin resistance in peripheral tissues combined with relative hormone deficiency. The main clinical manifestations of the disease are polyuria, polydipsia, and polyphagia. Without timely treatment, chronic hyperglycemia leads to damage to the blood vessels, nervous system, kidneys, and visual organ, which significantly increases the risk of disability and premature mortality [7, pp. 1–5].

Diabetes mellitus is one of the most common endocrine diseases and is considered one of the key medical and social problems of our time. The increasing prevalence of the disease is associated with urbanization, changing diets, an increase in the consumption of high-calorie foods, and a decrease in physical activity. Particularly challenging is the presence of latent forms of diabetes, in which the disease remains asymptomatic for a long time and is detected only through laboratory testing. In such circumstances, early diagnosis is crucial for preventing vascular and metabolic complications.

The clinical presentation of the disease depends on its type, rate of progression, and the degree of metabolic disturbances. Type 1 diabetes typically develops acutely and often manifests in young adults, while type 2 diabetes is characterized by gradual onset and a long latent course. In many cases, the condition is discovered incidentally during routine checkups or examinations for concomitant diseases [8, pp. 69–72].

The most common clinical signs include frequent urination, intense thirst, dry mucous membranes, decreased visual acuity, increased appetite, chronic fatigue, and decreased performance. The disease is also characterized by slow wound healing, a tendency toward skin and infectious processes, sleep disturbances, and weight fluctuations. It should be noted that differential diagnosis of the various types of diabetes is only possible based on clinical and laboratory data, as long-term diabetes can lead to nonspecific symptoms associated with the development of chronic complications.

The etiology of diabetes mellitus is multifactorial and is determined by the interaction of genetic predisposition with external and internal risk factors. The development of the disease can be associated with both damage to pancreatic β -cells and the development of insulin resistance. The main predisposing factors include a family history, excess body weight, physical inactivity, autoimmune processes, viral infections, and toxic exposures. Endocrine disorders, long-term use of glucocorticosteroids, and the presence of cardiovascular disease also play a significant role. Despite the rarity of congenital forms of the disease, genetic mechanisms significantly increase the likelihood of its manifestation later in life.

The pathogenesis of diabetes mellitus is formed as a result of the complex influence of genetic and environmental factors, which, in the presence of an individual predisposition, trigger a cascade of metabolic disorders leading to persistent hyperglycemia and its systemic consequences [9, p. 241–246].

Pathogenesis of diabetes mellitus

The pathogenesis of diabetes mellitus is a complex, multifactorial process resulting from the interaction of genetic predisposition and adverse environmental factors. Genetic mechanisms, which under certain conditions trigger abnormal immune and metabolic reactions, play a key role in the development of the disease. Types 1 and 2 diabetes mellitus differ in both their hereditary characteristics and their underlying pathophysiological mechanisms, despite the similarity of the underlying metabolic disturbances [9, pp. 241–246].

Type 1 diabetes mellitus is caused by an autoimmune attack on the β -cells of the islets of Langerhans. In the early stages of the disease, autoantibodies form against the surface antigens of insulin-producing cells, as well as against components of their cytoplasm and nucleus. In some cases, the immune system also produces antibodies against insulin itself. The gradual development of the autoimmune reaction leads to the progressive destruction of β -cells and a decrease in hormone secretion. Antigens released from damaged cells, including proinsulin, sustain and enhance the immune response, creating a vicious cycle that leads to the gradual loss of endogenous insulin production [8, pp. 70–72].

The pathogenesis of type 2 diabetes mellitus is different and is associated primarily with the development of insulin resistance. In the early stages of the disease, insulin secretion increases compensatorily, but chronic hyperinsulinemia leads to decreased receptor sensitivity to the hormone and disruption of intracellular signaling. Obesity, chronic inflammation, and lipotoxicity play a significant role, disrupting the normal function of insulin receptors and contributing to excess glucose production by the liver. As

the disease progresses, β -cells become functionally exhausted and their secretory activity decreases, leading to relative and then absolute insulin deficiency [7, pp. 1–5].

An additional pathogenetic mechanism is a disruption of the rhythm of insulin secretion, which is normally pulsatile. In metabolic disorders, this physiological rhythm is lost, reducing the hormone's effectiveness on peripheral tissues. Chronic hyperglycemia increases the production of amylin, a hormone secreted by β -cells simultaneously with insulin. Its excessive accumulation contributes to the formation of amyloid deposits in pancreatic islets, leading to structural tissue damage and further deterioration of β -cell function.

Despite differences in their developmental mechanisms, both types of diabetes mellitus result in similar metabolic consequences. A deficiency in effective insulin action impairs cellular glucose utilization, increases gluconeogenesis and lipolysis, causes an imbalance in protein metabolism, and leads to chronic hyperglycemia. The long-term persistence of these disturbances underlies systemic damage to organs and tissues, including micro- and macrovascular complications, which determine the severity of the disease and its long-term prognosis [6, pp. 2669–2675].

Clinical manifestations and characteristics of the course of diabetes mellitus

In most cases, diabetes mellitus is accompanied by significant metabolic disturbances, making it relatively easy to establish a diagnosis at the clinical stage. However, identifying the disease in the early and preclinical stages, when subjective complaints are absent or minimal, remains a significantly more challenging task. In such situations, targeted laboratory testing and screening programs play a crucial role. Early diagnosis is crucial, as timely initiation of therapy can prevent or significantly slow the development of vascular and neurological complications [4, pp. 19–22].

The clinical picture of diabetes mellitus is characterized by a polymorphism of symptoms reflecting the systemic nature of metabolic disorders. The first manifestations of the disease may include both specific signs of carbohydrate metabolism disorder and nonspecific general complaints. The most significant metabolic symptoms include thirst, frequent urination, persistent hunger, and weight changes. Patients may also experience increased fatigue, decreased performance, drowsiness, and muscle weakness.

Important clinical signs also include dry skin and mucous membranes, anogenital itching, a tendency toward recurrent skin infections, and delayed wound healing. Some patients experience dental problems, impaired peripheral sensitivity due to developing neuropathy, reproductive disorders, visual impairment, and early manifestations of cardiovascular disease. It should be emphasized that in the early stages of the disease, many of these symptoms may be perceived by patients as nonspecific and not requiring medical consultation. In some cases, hyperglycemia is discovered incidentally during routine screening.

The most characteristic clinical manifestations are associated with carbohydrate metabolism disorders and include the classic symptomatic triad. Polyuria develops as a result of osmotic diuresis associated with hyperglycemia and may be accompanied by an increase in daily urine volume to over 3 liters. Polydipsia is a compensatory response to fluid loss and is characterized by intense thirst and increased water intake. Polyphagia is caused by cellular energy deficiency and is often associated with weight changes—a decrease in the presence of insulin deficiency or an increase in the presence of obesity. These symptoms reflect underlying metabolic disturbances and are important diagnostic criteria for the disease [7, pp. 1–5].

The clinical course of diabetes mellitus varies significantly depending on its type. Type 1 diabetes mellitus is characterized by an acute onset and rapid progression of symptoms, is more common in children and young adults, and carries a high risk of developing diabetic ketoacidosis. Due to absolute insulin deficiency, patients require lifelong insulin replacement therapy.

In contrast, type 2 diabetes develops gradually and can remain asymptomatic for a long time. The disease is most often diagnosed in individuals over 40 years of age and is closely associated with excess weight and metabolic syndrome. Insulin resistance is the underlying cause, making lifestyle modification, weight loss, and oral hypoglycemic agents the primary treatment options. As the disease progresses, insulin therapy may become necessary.

Despite differences in their developmental mechanisms and clinical course, both types of diabetes require constant monitoring of glycemic levels. Maintaining carbohydrate metabolism within target limits is key to preventing chronic complications, including damage to the blood vessels, eyes, kidneys, and peripheral nervous system [6, pp. 2669–2675].

Table 1. Comparative Characteristics of Type 1 and Type 2 Diabetes Mellitus.

Criterion	Type 1 diabetes mellitus	Type 2 diabetes
The main pathogenetic mechanism	Autoimmune destruction of pancreatic β -cells, absolute insulin deficiency	Insulin resistance of tissues in combination with relative and then absolute insulin deficiency
Onset of the disease	Acute, rapid development (days–weeks)	Gradual, long-term asymptomatic course (months–years)
Age of manifestation	Most often children, teenagers and young adults	Mainly adults over 40 years of age (in recent years, also younger patients)
Body weight	Usually normal or decreased	Often overweight or obese
Main symptoms	Severe thirst, polyuria, sudden weight loss, weakness	Moderate symptoms: fatigue, dry mouth, itchy skin, slow wound healing
Risk of acute complications	High risk of diabetic ketoacidosis	Ketoacidosis is rare, hyperosmolar states are possible
Endogenous insulin level	Sharply reduced or absent	Normal or elevated in early stages, decreasing as progression occurs
Main approaches to treatment	Lifelong insulin therapy	Lifestyle modification, oral hypoglycemic agents, insulin if needed
Association with metabolic syndrome	Absent	Often associated with obesity, hypertension and dyslipidemia

Acute complications, laboratory diagnostics and non-drug therapy of diabetes mellitus

Acute complications of diabetes mellitus are life-threatening conditions resulting from sharp fluctuations in blood glucose levels and requiring immediate medical intervention. The most significant of these include hypoglycemia, diabetic ketoacidosis, hyperosmolar hyperglycemic state, and lactic acidosis. Hypoglycemia develops when blood glucose concentrations fall below critical values (usually less than 3.0 mmol/L) and is characterized by sudden weakness, tremors, sweating, tachycardia, severe hunger, and, in severe cases, loss of consciousness. Diabetic ketoacidosis is characterized by severe hyperglycemia, ketonemia, and metabolic acidosis, accompanied by dehydration, acetone breath, and abdominal pain. Hyperosmolar state, more commonly observed in type 2 diabetes mellitus, is associated with extremely high glucose levels and severe dehydration in the absence of pronounced ketosis. Lactic acidotic coma is caused by the accumulation of lactic acid and most often develops in elderly patients with underlying somatic pathology. All of these conditions are characterized by a high risk of mortality and require prompt diagnosis and intensive care [4, pp. 140–145].

Laboratory diagnosis of diabetes mellitus is based on an objective assessment of carbohydrate metabolism parameters and allows for the detection of both manifest and preclinical forms of the disease. The main diagnostic criteria include a fasting plasma glucose level ≥ 7.0 mmol/L, a glycated hemoglobin (HbA1c) concentration $\geq 6.5\%$, and the results of an oral glucose tolerance test, in which the glycemic level is ≥ 11.1 mmol/L 2 hours after a glucose load. Determination of HbA1c is considered the "gold standard" for assessing long-term glycemic control, reflecting the average blood glucose concentration over the previous 2-3 months. Of additional importance are urine tests for glucose and ketone bodies, as well as determination of the C-peptide level, which allows for the assessment of the functional activity of pancreatic β -cells and the differential diagnosis of various types of diabetes [2, pp. 19-24].

Extensive laboratory testing is aimed at clarifying the type of disease, assessing metabolic status, and early detection of complications. Determination of β -cell autoantibodies (GAD, ICA, IA-2), characteristic of the autoimmune process in type 1 diabetes, is of significant diagnostic value. Biochemical parameters, including a lipid profile, help assess cardiovascular risk, while creatinine levels, glomerular filtration rate (GFR), and microalbuminuria testing are used for the early diagnosis of diabetic nephropathy. Additional tests, such as fructosamine, liver function tests, complete blood count, and thyroid hormone levels, help identify associated disorders and assess the patient's overall condition.

The mainstay of type 2 diabetes treatment is non-drug therapy aimed at correcting risk factors and restoring metabolic balance. Lifestyle modifications are key, including a balanced diet with limited easily digestible carbohydrates and saturated fats, increased dietary fiber intake, and frequent meals. Regular moderate-intensity physical activity (at least 150 minutes per week) helps increase tissue sensitivity to insulin and improve carbohydrate metabolism. A 5-10% weight loss in overweight patients significantly reduces the severity of insulin resistance and lowers the risk of disease progression.

An important component of non-drug therapy is teaching patients self-monitoring skills, including regularly monitoring glucose levels, following dietary recommendations, and understanding the principles of complication prevention. Smoking cessation and limiting alcohol consumption further reduce the risk of cardiovascular events. It should be emphasized that lifestyle modification is essential at all stages of the disease and remains important even when drug therapy is prescribed. In the early stages of type 2

diabetes, with strict adherence to recommendations, it is possible in some cases to achieve sustained metabolic compensation and clinical remission.

Drug therapy, self-monitoring, complications and prevention of diabetes mellitus

Drug treatment for diabetes aims to achieve and maintain target glycemic control, prevent complications, and reduce cardiovascular risk. The treatment strategy is determined by the type of disease, the severity of metabolic disturbances, and the presence of comorbidities. For type 1 diabetes, the primary treatment method is lifelong insulin therapy, while for type 2 diabetes, oral hypoglycemic agents are initially used, followed by a transition to combination or insulin therapy as the disease progresses.

Metformin remains the first-line treatment for type 2 diabetes. It reduces hepatic glucose production and increases tissue sensitivity to insulin without causing severe hypoglycemia. If monotherapy is ineffective, medications from other pharmacological groups are used. Dipeptidyl peptidase-4 inhibitors enhance the incretin effect and stimulate insulin secretion in response to food intake. Sodium-glucose cotransporter-2 inhibitors promote the excretion of excess glucose in the urine and have proven cardio- and nephroprotective effects. Glucagon-like peptide-1 receptor agonists reduce body weight and improve glycemic control, while sulfonylureas stimulate endogenous insulin secretion. If oral medications are insufficient, insulin therapy is prescribed, including ultra-short-, short-, intermediate-, and prolonged-action medications. The selection of a treatment regimen is carried out individually by an endocrinologist, taking into account the clinical condition of the patient.

Self-monitoring is a crucial element of successful treatment, ensuring the patient's active participation in disease management. Regularly measuring blood glucose levels with a glucometer allows for timely adjustments to diet, physical activity, and medication dosages. Keeping a self-monitoring diary, monitoring body weight and blood pressure, and periodically determining glycated hemoglobin levels (at least once every 3-4 months) allow for an objective assessment of therapy effectiveness. Maintaining glycemia within target limits significantly reduces the risk of both acute and chronic complications and is essential for long-term disease management [4, pp. 140-145].

Chronic complications of diabetes mellitus develop as a result of prolonged exposure to hyperglycemia and are associated with damage to the vascular and nervous system. Microangiopathy includes diabetic retinopathy, a leading cause of blindness, nephropathy leading to chronic renal failure, and peripheral neuropathy, accompanied by sensory impairment and pain. Macroangiopathic complications include coronary heart disease, myocardial infarction, cerebrovascular accidents, and atherosclerotic vascular disease of the lower extremities. Of particular clinical significance is diabetic foot syndrome, characterized by the development of ulcerative necrotic processes and a high risk of amputation. Prevention of these complications is directly related to effective control of carbohydrate metabolism and correction of cardiovascular risk factors [17, pp. 88-90].

Primary prevention of diabetes, especially type 2, is based on promoting a healthy lifestyle and eliminating modifiable risk factors. A balanced diet with limited intake of easily digestible carbohydrates and saturated fats, regular physical activity for at least 30 minutes per day, maintaining a healthy weight, and avoiding unhealthy habits help improve tissue sensitivity to insulin and reduce the risk of developing the disease. Regular medical monitoring, including periodic blood glucose testing and blood pressure monitoring in at-risk individuals, is essential.

Thus, diabetes mellitus is one of the most significant non-communicable diseases of our time, becoming a global medical and social problem. The increasing incidence of the disease, driven by lifestyle changes and demographic processes, requires a comprehensive approach to its prevention and treatment. Achieving stable carbohydrate metabolism compensation remains a central goal of modern diabetology, as maintaining glycemia within target limits is the only proven method for preventing severe vascular complications and reducing mortality.

Modern medicine offers a wide range of therapeutic options, including innovative medications with organ-protective properties, continuous glucose monitoring systems, and high-tech insulin delivery systems. However, treatment effectiveness largely depends on the patient's adherence to therapy, their awareness, and their willingness to engage in long-term self-management. Educational programs and fostering a responsible attitude toward the disease are becoming crucial components of long-term patient management.

The prospects for the development of diabetology are linked not only to improved drug therapy methods but also to the development of fundamentally new approaches aimed at primary prevention and possible radical treatment of the disease. Research in cell technologies, regenerative medicine, and genetic engineering are opening up new avenues for therapy. Despite the chronic and progressive nature

of diabetes, modern medical science and active patient engagement allow this disease to be viewed as a manageable condition, ensuring a high quality of life and longevity.

Conclusion

Diabetes mellitus remains one of the most significant chronic noncommunicable diseases of our time, reflecting profound changes in lifestyle, dietary patterns, and demographic processes on a global scale. Its prevalence continues to grow, and the systemic nature of metabolic disturbances makes the disease a risk factor for severe cardiovascular, renal, neurological, and ophthalmological complications. Therefore, diabetes mellitus should be considered not only as a clinical problem but also as a complex medical and social phenomenon requiring an interdisciplinary and strategic approach to its management.

Modern advances in pathophysiology, pharmacotherapy, and medical technology have significantly expanded the possibilities for effective disease management. Innovative medications with proven organ-protective effects, continuous glucose monitoring systems, individualized treatment regimens, and patient education programs enable sustainable compensation of carbohydrate metabolism and significantly reduce the risk of complications. However, the key to successful therapy remains the patient's active participation, adherence to treatment, and commitment to long-term self-management.

The preventative focus of modern diabetology is becoming particularly important. Developing a healthy lifestyle, early detection of carbohydrate metabolism disorders, and timely intervention can significantly slow the progression of the disease and reduce its prevalence. At the same time, research in regenerative medicine, cell technologies, and gene therapy is opening up the prospect of fundamentally new treatment approaches aimed not only at compensating for, but also potentially restoring, lost endocrine functions.

Thus, despite the chronic and progressive nature of diabetes, the current state of medical science and clinical practice allows us to consider it a manageable condition. Consolidated efforts by physicians, researchers, healthcare systems, and patients themselves create the potential to reduce the burden of the disease, improve quality of life, and increase life expectancy, which defines the strategic goal for the further development of diabetology.

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PANCREATIC CANCER: MODERN REALITIES AND TRENDS**Arman Khozhayev***Professor of the S.N. Nugmanov Department of Oncology,
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This scientific and analytical work presents modern world and local-regional data on incidence, mortality, lethality and five-year survival rate of pancreatic cancer, a serious oncological disease. The issues of etiology and pathogenesis, modern approaches and principles of complex diagnostics, prospects for improving treatment results, as well as the prognosis are covered in detail. The epidemiological characteristics of this pathology in our republic are given in the context of the regions of the country.

Keywords: *oncology, endocrinology, pancreatic cancer, pancreatic neoplasms, biomarkers, diagnostic markers, RNA, miRNAs, single-cell RNA sequencing, DNA, cell-free DNA, genetics, screening, epidemiology, incidence, mortality, lethality, five-year survival rate, prognosis.*

Pancreatic cancer (PC) is a malignant neoplasm originating from the epithelium of the glandular tissue or pancreatic ducts [1]. The following diagnostic criteria are identified for PC:

Complaints and anamnesis: characteristic symptoms in the clinical picture of PC include pain, jaundice, itching, weight loss, loss of appetite, and fever. Pain is the most common symptom, observed in 70-85% of patients. Pain most often occurs as a result of tumor invasion or compression of nerve trunks; less commonly, it is caused by obstruction of the bile duct or Wirsung duct or peritoneal phenomena due to exacerbation of concomitant pancreatitis. With head cancer, pain is felt in the right hypochondrium or epigastric region; cancer of the body and tail is characterized by pain in the left hypochondrium and epigastric region, but can also manifest as a pain-like sensation in the right hypochondrium. Diffuse lesions are characterized by diffuse pain in the upper abdomen. In some patients, the pain remains localized in one area. In others, it radiates to the spine or interscapular region, and less commonly, to the right scapula. Tumors that obstruct the Wirsung duct and are accompanied by pancreatitis cause paroxysmal, encircling pain. The pain is noted to most often appear or intensify in the evening or at night, when the patient is supine, after large, especially fatty, meals, and after drinking alcohol. The pain is more severe with PC, especially when the tumor invades or compresses the solar plexus. In this case, the pain becomes

extremely severe, unbearable, and may become encircling. Patients adopt a forced position, bending their spine forward, leaning against the back of a chair, or leaning over a pillow pressed to the abdomen. This "hook" position is quite common in patients with advanced PC. Jaundice is the most prominent symptom of pancreatic head cancer. It occurs in 70-80% of patients. It is caused by tumor invasion of the bile duct and bile stasis in the biliary system. It occasionally occurs with cancer of the body and tail, in which case it is caused by compression of the common bile duct by metastases to the lymph nodes. Jaundice is rarely the first symptom of the disease; it is often preceded by pain or weight loss. Jaundice is mechanical in nature and develops gradually, steadily increasing in intensity. Jaundice is accompanied by discoloration of urine and stool. Stool becomes discolored. Urine becomes brown, reminiscent of beer. Sometimes changes in urine and stool occur before jaundice. Itching is caused by irritation of skin receptors by bile acids. With jaundice due to PC, itching occurs in most patients. It typically occurs after the onset of jaundice, most often with high bilirubin levels in the blood, but sometimes patients report itching of the skin even before jaundice. Itching significantly worsens the patient's well-being, disturbs their peace of mind, causes insomnia and increased irritability, and often leads to numerous scratches, the traces of which are visible on the skin. Weight loss is one of the most significant symptoms. It is caused by intoxication due to the developing tumor and impaired intestinal digestion due to obstruction of the bile and pancreatic ducts. Weight loss is observed in most patients and is sometimes the first symptom of the disease, preceding the onset of pain and jaundice. Loss of appetite occurs in more than half of patients. An aversion to fatty or meaty foods often develops. Weight loss and loss of appetite are accompanied by increasing weakness, fatigue, and sometimes nausea and vomiting. A feeling of heaviness after eating and heartburn are sometimes observed. Bowel function is often disrupted, with flatulence, constipation, and, occasionally, diarrhea. Stools are bulky, clay-gray in color, with an unpleasant, foul odor, and contain a large amount of fat.

Physical examination: symptoms of PC are a consequence of three clinical phenomena caused by the growing tumor: obstruction, compression, and intoxication. Compression is characterized by pain due to the growth of or compression of pancreatic nerve trunks by the tumor. Obstruction occurs when the growing tumor obstructs the common bile duct, duodenum, pancreatic duct, or compresses the splenic vein. Obstruction of the common bile duct leads to biliary hypertension, which is associated with mechanical jaundice, pruritus, liver and gallbladder enlargement, discolored stool, and dark urine. Biliary hypertension is a severe pathological condition that determines the patient's prognosis. It leads to dysfunction of the liver, cardiovascular and nervous systems, and metabolism, causing bradycardia, headache, apathy, and increased irritability. Prolonged and intense jaundice can lead to liver and hepatorenal failure, as well as cholemic bleeding. Tumor invasion of the duodenum leads to obstruction, clinically resembling pyloric stenosis. The phenomenon of intoxication is manifested by weight loss, decreased appetite, and general weakness. These symptoms are often observed in PC, as they are caused not only by the influence of the tumor itself, but also by impaired intestinal digestion [1].

Laboratory tests:

1) basic: cytological examination of a biopsy of a pancreatic tumor or liver metastasis (increase in cell size up to giant, changes in the shape and number of intracellular elements, increase in the size of the nucleus and its contours, varying degrees of maturity of the nucleus and other cellular elements, changes in the number and shape of nucleoli); histological examination of a biopsy specimen of a pancreatic tumor or liver metastasis (marked cellular polymorphism, increased cell size, pronounced hypochromia, large nuclei containing one or more nucleoli, glandular structures of cancer cells in the form of rosettes, numerous cells in mitosis);

2) additional: immunohistochemical examination of the biopsy and surgical material for a detailed determination of the tumor subtype; molecular genetic testing: due to the frequency of detection of mutations in the BRCA1 and BRCA2 genes of over 5%, as well as the significant impact of these mutations on the choice of chemotherapy regimen, their determination is advisable in all patients; a biochemical blood test for a tumor localized in the head of the pancreas is characterized by the development of mechanical ("subhepatic") jaundice - laboratory tests reveal hyperbilirubinemia.

Non-specific laboratory tests or in cases when deciding on the appointment of chemotherapy, the following are recommended: complete general (clinical) blood test, erythrocyte sedimentation rate; blood biochemistry: total protein, glucose, bilirubin, creatinine, urea, iron, alanine aminotransferase, aspartate aminotransferase, total bilirubin, alkaline phosphatase, plasma electrolytes (potassium, sodium, chloride), C-reactive protein; general (clinical) urine analysis; coagulology: fibrinogen, prothrombin, international normalized ratio, prothrombin time, prothrombin index, activated partial thromboplastin time, thrombin time; blood test for carcinoembryonic antigen, determination of the level of adenogenic cancer

antigen CA 19-9 in order to assess the current clinical situation and, if they increase, for further monitoring of the disease. A baseline assessment should be performed against the background of biliary decompression, normal bilirubin levels, and resolution of inflammation. A blood test for chromogranin A is required for differential diagnosis with neuroendocrine tumors.

Instrumental examinations:

1) *basic: abdominal ultrasound – primary diagnosis of pancreatic lesions; multislice computed tomography of the abdominal organs with bolus contrast allows for the diagnosis of PC, assessment of vascular invasion, and identification of metastases (lymph nodes, liver, abdominal cavity); fibrogastroduodenoscopy (to assess tumor spread);*

2) *additional: endoscopic retrograde cholangiopancreatography – is important in the diagnosis of pancreatic and bile duct obstruction: magnetic resonance imaging with magnetic resonance cholangiopancreatography provides information on the condition of the pancreatic duct and bile ducts; positron emission tomography/computed tomography is one of the most sensitive and informative methods for assessing the extent of tumor spread in the pelvis, abdominal cavity, retroperitoneal space, chest, brain, soft tissues, bones, and for identifying "small" tumors, relapses, and metastases.*

In any sequence of instrumental research methods, it is necessary to establish the tumor nature of changes in the pancreas and the extent of the tumor [1].

Hirabayashi K. et al. [2] note in their work that cytology is a useful method for diagnosing pancreatic neoplasms. Although endoscopic ultrasound-guided fine-needle aspiration has recently become the mainstream method for the diagnosis of pancreatic neoplasms, pancreatic juice and pancreatic duct brushing cytology continue to be useful diagnostic methods for the investigation of pancreatic neoplasms. Diagnoses using pancreatic cytology are primarily based on the features related to tumor cells; however, evaluation of the background features provides important information that could further aid the diagnosis. Pancreatic neoplasms show various histological types, each of which is associated with its own characteristic background features. The necrotic background, desmoplastic stroma, and presence of cancer-associated fibroblasts are background features of pancreatic ductal adenocarcinoma, a mucinous background is associated with intraductal papillary mucinous neoplasms and mucinous cystic neoplasms, and hyaline globules are observed in solid pseudopapillary neoplasms. However, some background features are associated with more than one histological type of pancreatic neoplasm, highlighting the importance to base a diagnosis on the results of a comprehensive analysis of not only the background features but also the tumor cells. The authors presented key background cytological features of pancreatic neoplasms that can serve as a guide for improved diagnosis and research.

PC is a malignant neoplasm with an extremely poor prognosis; thus, early diagnosis and treatment are desirable. Although the accuracy of PC diagnosis has improved in recent years due to the development of diagnostic imaging, it is still necessary to carry out biopsy and cytology to differentiate between benign and malignant neoplasms and to determine the histological type. Pancreatic juice cytology and pancreatic duct brushing cytology have long been the major diagnostic methods for pancreatic neoplasms; however, the recent development and application of endoscopic ultrasound-guided fine-needle aspiration (EUS-FNA) has substantially aided and improved the cytological diagnosis of pancreatic neoplasms. Pancreatic juice cytology and pancreatic duct brushing cytology are mainly used for investigating neoplasms involving the large pancreatic ducts, such as pancreatic ductal adenocarcinoma (PDAC) and intraductal papillary mucinous neoplasms (IPMNs), whereas EUS-FNA is now more commonly used for pancreatic neoplasms that have less association with the pancreatic ducts, such as neuroendocrine neoplasms, acinar cell carcinoma, serous cystic neoplasms, mucinous cystic neoplasms, and solid pseudopapillary neoplasms. In cytology, the diagnosis of pancreatic neoplasms is based mainly on morphological evaluation of the tumor cells; however, background features such as the presence of necrosis or mucin also provide important information to assist with the diagnosis. In conclusion, our colleagues point out that there are various histological types of pancreatic neoplasms, and characteristic background features for each type that may be useful for diagnosis have been identified. However, as certain background features also overlap between histological types, it is important to make a comprehensive diagnosis by carefully observing not only the background features but also the characteristics of tumor cells and atypical cells. The diagnostic utility of background features, such as necrotic background or cancer-associated fibroblasts, in pancreatic juice cytology and/or pancreatic duct brushing cytology in early-stage PDAC with pancreatic duct stenosis or dilation is still not well understood. Therefore, further studies on the diagnostic utility of background findings in early-stage PDAC are needed [2].

Selvaggi S.M. in her study compared the use of fine-needle aspiration biopsy and needle biopsy for the diagnosis of pancreatic neoplasms [3]. The author emphasizes that EUS-FNA is highly sensitive and

specific in the detection and diagnosis of pancreatic neoplasms. EUS-guided needle core biopsy has been used alone or as an adjunct to maximize diagnostic yield. From January 1, 2018 through December 21, 2020, the Cytopathology Laboratory processed 374 FNAs from solid pancreatic masses of which 332 (89%) had concurrent pancreatic biopsies and form the basis of this study. Of the 332 FNAs, 173 (52%) were positive/suspicious for pancreatic adenocarcinoma, 33 (10%) were positive for a neoplasm, 20 (6%) were atypical 19 (6%) were negative and 87 (26%) were non-diagnostic. Biopsies were concordant in 248 (75%) cases and discordant in 84 (25%) cases. Of the 84 discordant cases, 29 (35%) had neoplastic cells on FNA of which 14 were atypical, 11 were negative and 4 were nondiagnostic on core biopsy. Of the 18 (21%) FNAs with atypical cells, 8 showed adenocarcinoma on core biopsy. Thirty-seven nondiagnostic FNAs showed adenocarcinoma on 25 (70%) core biopsies. If nondiagnostic FNAs were included, FNA sensitivity was 89% and specificity; 100%, and both were 100%, if the nondiagnostic cases were excluded. The needle core biopsy sensitivity was 91% and specificity; 100%. Summarizing the conducted research, the author says that both FNAs and core biopsies show high sensitivity and specificity in the detection of pancreatic neoplasms. However, utilization of both techniques enhances cellular yields; in particular unsatisfactory FNAs, and often provides sufficient material for ancillary tests in this era of precision medicine [3].

In the scientific work of Lv G. et al. [4], the researchers summarized new modern knowledge on the sequencing of individual cells in pancreatic neoplasms, taking into account the methods used, tumor heterogeneity and treatment methods.

According to the authors, pancreatic neoplasms, including PDAC, IPMN and pancreatic cystic neoplasms, are the most puzzling diseases. Numerous studies have not brought significant improvements in prognosis and diagnosis, especially in PDAC. One important reason is that previous studies only focused on differences between patients and healthy individuals but ignored intratumoral heterogeneity. In recent years, single-cell sequencing techniques, represented by single-cell RNA sequencing (scRNA-seq), have emerged by which researchers can analyse each cell in tumours instead of their average levels. Based on the conducted research, the authors state that pancreatic neoplasms, especially PDAC, remain the most complex and malignant disease due to their high heterogeneity. Single-cell sequencing benefits from its single-cell resolution and has become the most appropriate approach to uncover the underlying mechanisms of PDAC. Several frameworks and algorithms of single-cell sequencing have been applied, such as copy number karyotyping of aneuploid tumors, minimally invasive adenocarcinoma and SPOT-light, among which scRNA-seq combined with the spatial transcriptome has presented more obvious advantages. scRNA-seq enables rapid determination each cellular gene-expression patterns of thousands of individual cells. By using this emerging sequencing technology, scientists have revealed high heterogeneities in cancer cells, the tumour environment, circulating tumour cells, and the progression from precancerous lesions to PDAC. Immune checkpoint inhibitors have shown cooperates in many cancers; however, PDAC is still resistant to them. Recent studies found that a few new targets and inhibitors had an obvious ability to suppress PDAC growth when they were combined with immune checkpoint inhibitors. In conclusion, single-cell sequencing provides us with novel insights into intratumoral heterogeneity, subclusters identification, unique genes mutations, and dynamic evolution in PDAC. However, some shortcomings limit its large-scale use. As a high-throughput protocol, scRNA-seq only captures a fraction of molecules, ranging from 5% to 20% RNA physically present in cells. Meanwhile, enzymes used to obtain single-cell suspensions can degrade RNA, which is more pronounced in PDAC. The batch effect is frequently observed as samples are collected at different periods. These technical noises mentioned above generate bias and make it more difficult to differentiate rare cell types. Meanwhile, there are many algorithms and parameters for single-cell analysis that make novices too difficult to choose a correct combination. Another limitation is the expensive cost of experiments [4].

Vicentini C. et al. [5] note that pancreatic and peri-pancreatic neoplasms encompass a variety of histotypes characterized by a heterogeneous prognostic impact. Researchers point out that MicroRNAs (miRNAs) are considered efficient candidate biomarkers due to their high stability in tissues and body fluids. They applied Nanostring profiling of circulating exosomal miRNAs to distinct pancreatic lesions in order to establish a source for biomarker development. A series of 140 plasma samples obtained from patients affected by pancreatic ductal adenocarcinoma (PDAC, n = 58), pancreatic neuroendocrine tumors (Pancreatic neuroendocrine tumours, n = 42), IPMN, n = 20, and ampulla of Vater carcinomas, n = 20 were analyzed. Comprehensive miRNA profiling was performed on plasma-derived exosomes. Relevant miRNAs were validated by quantitative reverse-transcription polymerase chain reaction (qRT-PCR) and in situ hybridization (ISH). Lesion specific miRNAs were identified through multiple disease comparisons. Selected miRNAs were validated in the plasma by qRT-PCR and at tissue level by ISH. The

researchers leveraged the presence of clinical subtypes with each disease cohort to identify miRNAs that are differentially enriched in aggressive phenotypes. The authors emphasize that this study shows that pancreatic lesions are characterized by specific exosomal-miRNA signatures. Our colleagues also provided a bioresource for future explorations aimed to understand the biological and clinical relevance of such signatures.

Faur A.C. et al. [6] in their work they say that PC has a low incidence rate but a high mortality, with patients often in the advanced stage of the disease at the time of the first diagnosis. If detected, early neoplastic lesions are ideal for surgery, offering the best prognosis. Preneoplastic lesions of the pancreas include pancreatic intraepithelial neoplasia and mucinous cystic neoplasms, with intraductal papillary mucinous neoplasms being the most commonly diagnosed. The study focused on predicting PC by identifying early signs using noninvasive techniques and artificial intelligence (AI). A systematic English literature search was conducted on the PubMed electronic database and other sources. Our colleagues obtained a total of 97 studies on the subject of pancreatic neoplasms. The final number of articles included in this study was 44, 34 of which focused on the use of AI algorithms in the early diagnosis and prediction of pancreatic lesions. AI algorithms can facilitate diagnosis by analyzing massive amounts of data in a short period of time. Correlations can be made through AI algorithms by expanding image and electronic medical records databases, which can later be used as part of a screening program for the general population. AI-based screening models should involve a combination of biomarkers and medical and imaging data from different sources. This requires large numbers of resources, collaboration between medical practitioners, and investment in medical infrastructures.

As the researchers note to improve the clinical management and prognosis for patients with PC, new diagnostic methods should be developed to identify precursor lesions. AI is a tool that can offer a personalized approach in this regard by analyzing a large quantity of heterogeneous data and can also help in decision-making, increasing the prediction accuracy for an early diagnosis. As for future prospects, the authors conclude that for PC, a cost-effective screening method for early lesions is needed. AI models developed for a diverse group of patients from high-risk PDAC cohorts belonging to broad datasets from different sources can be of great use for improving PDAC treatment outcomes and enhancing diagnostic precision. AI methods represent a needed step to reach a standardized interpretation of patient data and investigations while reducing human bias or error. For this, a wide range of data from different sources is necessary. All of these data have a central role in training AI methods in diagnosing PC and establishing the most accurate algorithm to be used for such a diagnosis. Correlations can be made through AI algorithms by expanding the image and electronic medical record databases, which will significantly improve the diagnostic accuracy and provide an early diagnosis for PC patients, thereby producing a better prognosis and more effective therapy. AI creates a common ground in diagnosing PC that can be standardized and used for the general population. Such an AI model should contain a combination of biomarkers, medical data, and imaging data obtained by alternating computed tomography, endoscopic ultrasound-guided, and magnetic resonance imaging testing so that maximized accuracy and early diagnosis with noninvasive techniques can be achieved. The coronavirus disease 2019 pandemic has produced a model for forming an international infrastructure that can be studied with AI algorithms and even used for predicting and early diagnosing cancers. The collaboration between scientists and academic centers has shown that humans from different countries and continents can work together to share information in a common attempt to save lives while creating a vast database. This will require resources, global solidarity, and support investment in medical infrastructures worldwide. However, the need to develop health infrastructure and multidisciplinary research studies is crucial, as the pandemic situation has already shown [6].

Conducted analysis [6] of the current diagnostic methods for detecting PC noninvasively with an emphasis on early lesions has revealed a series of common features and limitations: published studies about predicting early lesions in PC are lacking. For PC diagnosis, noninvasive tests such as imaging, tumor marker analysis, and population-based studies can be used to train AI algorithms to identify features, patterns, and subtle changes that can help classify pancreatic lesions and build predictive models that can improve the awareness of the risk of pancreatic neoplasia. Published studies typically included only small samples from a limited number of cases. The analysis of these studies focused mostly on just one type of investigation (radiomics features, personal data, biomarkers, or genomic features without making correlations between all the data that a physician analyses for a diagnosis of PC in a specific patient). A high percentage of the studies only performed internal validation, so bias and overfitting can constitute a problem when generalizing their conclusions. Commonly, for machine diagnosis, the mechanism that generates the output is not clearly explained, so assessing how a specific AI algorithm makes its final

diagnosis remains controversial. AI algorithms for assessing pancreatic volumes with and without tumors are time- and cost-consuming that are usually run manually and in direct relation with the radiologist's experience. Finding an AI-driven automated volumetric segmentation algorithm is difficult because of the variations in shape, the shallowness of the boundaries, and the small size of the pancreas. Pancreatic tumors smaller than 2 cm frequently have inconspicuous borders with high similarity to the surrounding tissues on radiomics analysis, making early lesion diagnosis challenging. However, AI methods have the potential to improve accuracy and support clinical decisions for the preoperative diagnosis of pancreatic lesions and to aid in the surgical management and prognosis of PC.

Hsieh M.J. et al. [7] in their study note that PC is a highly lethal malignancy due to the cancer routinely being diagnosed late and having a limited response to chemotherapy. PDAC is the most common form of pancreatic malignant tumor, representing more than 85% of all PCs. In the present study, authors characterized the phenotypes of concomitant P53 and adenomatous polyposis coli (APC) mutations in pancreatic neoplasms driven by the oncogene Kirsten Rat Sarcoma Viral Oncogene Homolog (KRAS) in genetically modified mice (GEMM). In this GEMM setting, APC haploinsufficiency coupled with P53 deletion and KRASG12D activation resulted in an earlier appearance of pancreatic intraepithelial neoplasia lesions and progressed rapidly to highly invasive and metastatic PDAC. Through a microarray analysis of murine PDAC cells derived from our APC-deficient PDAC model, the researchers observed that APC loss leads to upregulated CD34 expression in PDAC. CD34 is a member of a family of single-pass transmembrane proteins and is selectively expressed in hematopoietic progenitor cells, vascular endothelial cells, interstitial precursor cells, and various interstitial tumor cells. However, the functional roles of CD34 in PC remain unclear. Thus, in this study, our colleagues explored the mechanisms regarding how CD34 promotes the deterioration of pancreatic malignancy. These results demonstrated that the increased expression of CD34 induced by APC inactivation promotes the invasion and migration of PDAC cells, which may relate to PDAC metastasis in vivo. Collectively, this study provides first-line evidence to delineate the association between CD34 and the Wingless / Int-1 signaling (APC/Wnt) pathway in PDAC, and reveals the potential roles of CD34 in PDAC progression.

The authors' analysis revealed that CD34 is predominantly expressed on hematopoietic progenitor cells and endothelial progenitors, and has been widely used as a stem and progenitor cell marker. The results of the present study provided important evidences revealing the association between CD34 and the APC/Wnt pathway in PDAC, and authors demonstrated the potential roles for CD34 upregulation induced by APC inactivation in promoting PDAC cell growth, migration and invasion. Moreover, because CD34 is thought to be a biomarker for stem cells to maintain self-renewal and proper stemness, CD34 could be a novel drug candidate for the treatment of PDAC harboring APC mutations [7].

Huang B. et al. [8] devoted their scientific research to the study of IPMN. IPMNs are a commonly identified non-invasive cyst-forming pancreatic neoplasms with the potential to progress into invasive pancreatic adenocarcinoma. There are few in vitro models with which to study the biology of IPMNs and their progression to invasive carcinoma. Therefore, authors generated a living biobank of organoids from 7 normal pancreatic ducts and 10 IPMNs. The researchers characterized 8 IPMN organoid samples using whole genome sequencing and characterized 5 IPMN organoids and 7 normal pancreatic duct organoids using transcriptome sequencing. Our colleagues identified an average of 11,344 somatic mutations in the genomes of organoids derived from IPMNs, with one sample harboring 61,537 somatic mutations enriched for T->C transitions and T->A transversions. Recurrent coding somatic mutations were identified in 15 genes, including KRAS, GNAS, RNF43, PHF3, and RBM10. The most frequently mutated genes were KRAS, GNAS, and RNF43, with somatic mutations identified in 6 (75%), 4 (50%), and 3 (37.5%) IPMN organoid samples respectively. On average, they identified 36 structural variants in IPMN derived organoids, and none had an unstable phenotype (>200 structural variants). Transcriptome sequencing identified 28 genes differentially expressed between normal pancreatic duct organoid and IPMN organoid samples. The most significantly upregulated and downregulated genes were CLDN18 and FOXA1. Immunohistochemical analysis of FOXA1 expression in 112 IPMNs, 113 mucinous cystic neoplasms, and 145 pancreatic ductal adenocarcinomas demonstrated statistically significant loss of expression in low-grade IPMNs ($p < 0.0016$), mucinous cystic neoplasms ($p < 0.0001$), and pancreatic ductal adenocarcinoma of any histologic grade ($p < 0.0001$) compared to normal pancreatic ducts. These data indicate that FOXA1 loss of expression occurs early in pancreatic tumorigenesis. As the authors note, this study highlights the utility of organoid culture to study the genetics and biology normal pancreatic duct and IPMNs.

In this study, our colleagues generate a living biobank of organoids derived from 7 normal human pancreatic ducts and 10 human IPMN samples. They also present the characterization of somatic

alterations in these IPMN organoids using whole genome sequencing. Furthermore, the researchers use transcriptomic sequencing to identify genes differentially expressed between normal pancreatic duct and IPMN organoids. The authors emphasize that their study documents a biobank of IPMN and normal pancreatic duct organoids, characterized by genomic and transcriptomic sequencing, a unique resource for the interrogation of these precancerous lesions. Using whole genome sequencing and RNA-Seq they identified potential drivers of IPMN tumor development. These included 12 genes with recurrent somatic mutations and 28 genes that were differentially expressed when compared to normal pancreatic duct. The obtained results demonstrate that organoid culture is an effective tool for analyzing small precursor lesions at – omics scale to identify critical molecular alterations in precious human tissue samples [8].

Jain M. et al. [9] in their work say that Cell-free DNA (cfDNA) analysis-based liquid biopsy is a rapidly emerging diagnostic and prognostic tool in PDAC. KRAS point mutations are the main biomarkers used for the detection of tumor cfDNA. However, there is another less studied yet frequent genetic alteration in this gene, namely copy number gain (CNG). The aim of this study was to evaluate the diagnostic and prognostic potential of KRAS CNG analysis in plasma and bile of patients with PDAC using droplet digital polymerase chain reaction (ddPCR). This study included healthy volunteers ($n = 69$), patients with PDAC ($n = 94$), and other pancreatic neoplasms (OPN) ($n = 17$). The sensitivity and specificity of KRAS CNG compared to the control group were 16% and 100% (AUC-ROC - 0.580), and compared to the OPN group, 16% and 94% (AUC-ROC - 0.554), respectively. Addition of KRAS point mutations to the analysis increased the sensitivity to 65% (AUC-ROC - 0.824 and 0.801, respectively). Bile exhibited an equal KRAS CNG detection rate compared to plasma (20% vs. 16%). KRAS CNG was not associated with clinical parameters, except prognosis. The probability of survival was worse in patients with KRAS CNG (hazard ratio - 3.54; 95% confidence interval: 1.55-8.12; $p = 0.001$). KRAS CNG in cfDNA might be a promising biomarker for both diagnostic and prognostic purposes in PDAC.

In the course of the study, the authors state that copy number variants are an important yet underexplored aspect of cancer molecular biology. This exploratory study has demonstrated that not only are they detectable in cell-free DNA (cfDNA) of plasma and bile, but also they might be relevant to predicting poor survival in PDAC patients. The prognostic potential of KRAS CNG in plasma cfDNA, especially in combination with point mutations in this gene, might be useful to guide therapeutic decisions, for example, to identify patients requiring neoadjuvant chemotherapy or those who may benefit from additional imaging prior to treatment. However, the clinical implications of this kind of cfDNA analysis require further investigation. The ddPCR assay for KRAS CNG analysis presented in this work might be easily reproduced in any laboratory equipped with a ddPCR instrument, and our colleagues hope that it will be useful for future studies on the topic in PDAC and beyond [9].

An interesting study was conducted by Angerilli V. et al. [10]. They analyzed a cohort of 49 high-grade gastro-entero-pancreatic neoplasms (HG GEP-NENs) by targeted Next-Generation Sequencing (TrueSight Oncology 500), RNA-seq, and immunohistochemistry for p53, Rb1, SSTR-2A, and PD-L1. As the authors note HG GEP-NENs can be stratified according to their morphology and Ki-67 values into three prognostic classes: neuroendocrine tumors grade 3 [(neutrophil extracellular traps (NETs) G3)], neuroendocrine carcinomas with Ki-67 < 55% [(neuroendocrine carcinomas (NECs) <55%)] and NECs with Ki-67 $\geq$ 55% (NECs $\geq$ 55%). Frequent genomic alterations affected TP53 (26%), APC (20%), KRAS and MEN1 (both 11%) genes. NET G3 were enriched in MEN1 ($p = 0.02$) mutations, while both NECs groups were enriched in TP53 ($p = 0.001$), APC ($p = 0.002$) and KRAS ($p = 0.02$) mutations and tumors with TMB $\geq$ 10 muts/Mb ($p = 0.01$). No differentially expressed (DE) gene was found between NECs <55% and NECs $\geq$ 55%, while 1129 DE genes were identified between NET G3 and NECs. A slight enrichment of CD4+ and CD8+ T cells in NECs and of cancer-associated fibroblasts and macrophages (M2-like) in NET G3. Multi-variate analysis identified histologic type and Rb1 loss as independent prognostic factors for overall survival. This study showed that GEP-NET G3 and GEP-NECs exhibit clear genomic and transcriptomic differences, differently from GEP-NECs <55% and GEP-NECs $\geq$ 55%, and provided molecular findings with prognostic and potentially predictive value.

Mazer B.L. et al. [11] in their fundamental study emphasize that most patients with PC present with advanced stage, incurable disease. However, patients with high-grade precancerous lesions and many patients with low-stage disease can be cured with surgery, suggesting that early detection has the potential to improve survival. While serum CA19-9 has been a long-standing biomarker used for PC disease monitoring, its low sensitivity and poor specificity have driven investigators to hunt for better diagnostic markers. In their work, our colleagues examined the latest advances in genetics, proteomics, imaging, and artificial intelligence, which offer opportunities for the early detection of curable pancreatic neoplasms. As an expert on this work notes, from exosomes, to circulating tumor DNA, to subtle changes

on imaging, we know much more now about the biology and clinical manifestations of early pancreatic neoplasia than we did just five years ago. The overriding challenge, however, remains the development of a practical approach to screen for a relatively rare, but deadly, disease that is often treated with complex surgery. It is our hope that future advances will bring us closer to an effective and financially sound approach for the early detection of PC and its precursors.

The authors' analysis revealed that at first glance, PC seems to be an ideal target for screening and early detection. It is a highly lethal cancer, and most patients do not develop signs and symptoms until late in the course of their illness. A variety of methods have been developed to screen for early disease. From blood CA19-9 levels to circulating tumor DNA, each method has advantages and disadvantages, and it is likely that the best approach will incorporate multiple complementary modalities. It is also likely that artificial intelligence, whether applied to electronic patient medical records or to image analysis, will play a role in identifying the highest risk individuals. Screening for PC, however, must take into account the rarity of the disease in the general population, the costs of false positive test results, and the real potential for overtreatment of low-risk lesions.

According to an expert on this study if we wait until patients develop symptoms from PC, most will die within months of their diagnosis. There are, however, a number of potential approaches to the earlier diagnosis of PC and its precursors in asymptomatic individuals. The unresolved challenge is that none of the existing approaches have the sensitivity and specificity needed to effectively screen the general population. While combining tests can improve sensitivities, even these combinations fall short. Existing approaches to screening, therefore, have to be focused on populations at greatest risk of the disease. Towards this end, screening efforts to date have targeted individuals with a strong family history of PC or a known pathogenic germline variant that predisposes to PC. Other groups with a heightened cancer risk that have not yet been clinically targeted include cigarette smokers, obese individuals, and adults with new onset diabetes mellitus. Screening programs that target high-risk groups and utilize imaging modalities like magnetic resonance imaging and endoscopic ultrasound have generated promising results. These programs, however, have thus far been relatively expensive and limited in scope [11].

AI has the potential to be a significant advance. AI-based algorithms can be applied to medical records and to imaging. AI-based algorithms can be trained to scour electronic patient medical records and imaging scans for subtle patterns, which may not be recognizable to the human eye, yet that indicate an increased risk of PC. Clinicians could then be alerted and even guided on the best ways to evaluate their patients further. AI-based algorithms have already been built that can evaluate computed tomography and other scans for subtle changes caused by low-stage, curable, pancreatic neoplasms. These algorithms could quietly run in the background, evaluate the millions of computed tomography and other scans that are already being performed for other indications, and have the potential to identify changes in the pancreas that radiologists could easily miss in their day to day practice. Again, the program could alert the radiologist to look more closely at the images of the pancreas, and even suggest the best next steps to evaluate the subtle AI-detected changes. This approach has the advantage of not requiring additional testing until an abnormality is discovered. But enthusiasm about AI technologies must be tempered by the yet unproven real-world benefit and privacy concerns of these tools.

The growing emphasis on early detection of PC and its precursors should be balanced with a consideration of the costs and harms of screening. Costs are incurred during acquisition of the screening cohort, initial testing, confirmatory imaging and biopsies, surgery and other treatments, and post-treatment follow up and care. Screening can also cause serious patient harm. This harm includes the psychological stresses that individuals will feel when they are told that they are at increased risk, the worries from an initial result, and the medical complications that can occur from unnecessary biopsies and surgeries. The pancreas lies deep in the abdomen, and surgical resection of the head of the gland (the pancreaticoduodenectomy) is associated with a 1-2% operative mortality rate and significant incidence. If this surgery is done for a false positive screening test or low-risk precursor lesion, we have done significant harm to the individual.

As the researchers look forward to the next five to ten years, authors hope that new technical advances will improve the sensitivity and specificity of screening for PC. Our colleagues also anticipate a better understanding of who is at risk, and of which groups will benefit most from screening. The development of new AI-based tools might improve screening approaches and help refine the identification of at-risk populations. The challenge, then, will be to fulfill these goals in a cost-effective manner that minimizes patient harm and to prove, prospectively and rigorously, the real-world value of these interventions before widespread implementation [11].

Now, regarding this pathology in our country at the national level. The incidence of PC in the

Republic of Kazakhstan in 2023 was 6.5 per 100,000 population (6.0 in 2022), with a growth rate of 7.6% compared to the previous year. It ranked 8th among all nosological forms of malignant neoplasms, accounting for 1,290 cases in absolute numbers (1,175 cases in the previous year). The proportion of cases diagnosed for the first time, recorded by oncology organizations, was 3.5% (3.3% in 2022), moving up one place from 12th place to 11th place. In this case, 631 men fell ill (the proportion is 3.9%), women – 659 (the proportion is 3.2%) [12].

The rate of PCa above the national average was established in 10 regions of the country: Kostanay – 11.3 (the maximum rate); North Kazakhstan – 10.7; Pavlodar – 10.6; East Kazakhstan and Abay – 10.0; West Kazakhstan – 9.1; Karaganda – 8.4; Akmola – 8.1; Zhetysu – 7.9 regions and the city of Almaty – 7.3. This indicator is below the national average in the remaining 10 regions: Turkestan – 3.1 (the lowest rate); Mangistau – 3.3; Kyzylorda and Almaty – 3.8; Zhambyl – 4.2; Atyrau – 5.0; the city of Shymkent – 5.2; Ulytau – 5.9; Aktobe – 6.1 regions and the city of Astana – 6.3 per 100,000 population.

The mortality rate from this pathology was 4.1 per 100,000 population with a growth rate of 5.7% compared to the previous year (3.8 in 2022).

The regions where the mortality rate from PC is above the national average (4.1 per 100,000 population) include: East Kazakhstan – 7.3 (the highest level); Abay and Akmola – 6.6; Pavlodar and Kostanay – 6.4; West Kazakhstan – 5.6; the city of Almaty – 4.9; Karaganda – 4.6; the city of Astana – 4.5. The North Kazakhstan region is on par with the national average. The lowest rates are recorded in the Atyrau and Turkestan regions – 2.3, followed by: Aktobe, Kyzylorda and Mangistau – 2.6; the city of Shymkent – 2.8; Zhambyl – 2.9; Almaty – 3.0; Ulytau – 3.2; Zhetysu – 3.9 regions per 100,000 population [12].

The one-year lethality rate was 52.1% (51.0% in 2022), which is the highest percentage among all nosological forms of malignant tumors; every second patient dies in the first year after the diagnosis of this formidable disease. Moreover, the ratio between the one-year lethality and advanced stage (stage IV) was 1.5 (in 2022 – 1.4). At the same time, we recall that the value furthest from “1” is the worst ratio between the one-year lethality and neglect rates.

Now, regarding preventive examinations. It should be noted that during large-scale preventive examinations of the population in 2023, significantly more patients with malignant neoplasms were actively identified than in 2022. This is 25,193 patients compared to 23,623 patients identified in 2022, i.e., +6.6%. This is due to the continued easing of the epidemiological situation due to the coronavirus and the increased availability of preventive care for the population. The proportion of patients identified during preventive examinations increased from 62.0% to 62.4% of the total number of patients identified for the year.

Of course, early diagnosis rates are very important when analyzing the epidemiological situation. Overall, of all cancer cases detected in all locations, the proportion of forms detected in the early stages (stages 0, I-II) increased in 2023 from 66.3% to 67.9%.

Regarding PC, the early detection rate of this pathology during preventive examinations increased from 27.9% to 34.0%. The absolute number of patients with PC identified during preventive examinations was 574 (577 in the previous year). Of these, 195 were in the early stages (compared to 161 in 2022).

The regions where the proportion of patients with early stage I of the pathology in question is above the national average (4.5% and 4th place among the worst indicators only after liver cancer (3.8%), nasopharynx (3.7%) and laryngopharynx (2.7% - the worst indicator) include the following regions: North Kazakhstan – 16.1%; (the best indicator); Kyzylorda – 12.5%; Zhambyl – 11.8%; Zhetysu – 9.4; Atyrau – 8.8; Abay – 8.3%; Turkestan – 6.2%; the city of Astana – 5.9%; West Kazakhstan – 5.3%.

The lowest indicators of early diagnosis were recorded in: Almaty, Mangistau, Ulytau regions and the city of Shymkent – not a single patient (0.0% is the worst indicator). They are followed by the following regions: Kostanay – 1.1%; Karaganda – 1.2%; East Kazakhstan – 1.6%; Aktobe – 1.8%; Akmola – 3.3%; Pavlodar and the city of Almaty – 2.5% [12].

The regions where the proportion of patients with PC detected at stages I-II is above the national average (26.6%) include the following regions. North Kazakhstan region stands out separately, where every second patient was detected in the early stages of the disease – 55.4%. Then come: Atyrau – 38.2%; Zhambyl – 35.3%; Zhetysu – 32.1%; Kyzylorda – 31.3%; Kostanay and Abay – 30.0; Aktobe – 26.8% of the regions. Low rates of early diagnosis were recorded in Ulytau – 7.7% (the worst result in the country); Mangistau – 11.5%; Almaty – 18.2%; the city of Shymkent – 18.3%; Turkestan – 18.5%; West Kazakhstan – 21.1%; East Kazakhstan – 22.6%; Pavlodar – 24.1%; the city of Astana – 24.7%; Akmola – 25.0%; the city of Almaty – 25.3%; Karaganda – 25.6% regions [12].

As the data above clearly demonstrates, there is a significant range in early diagnosis rates across

the country, from very good to alarming. While migration and other factors influencing early diagnosis rates must be taken into account, the results obtained provide a reason for oncologists, endocrinologists, radiologist, ultrasound technician, and general practitioners to continue to improve. Improving early diagnosis rates for malignant tumors remains a fundamental tenet and a key objective of medicine as a whole, and remains a pressing issue today.

The proportion of stage IV PC among all malignant neoplasms was 36.5%, ranking first among all malignant neoplasms in the country. Overall, in 2023, the proportion of stage IV malignant neoplasms across the republic, across all nosologies, decreased from 12.58 to 11.7% (from 4,790 to 4,735 patients). Naturally, this was due to other tumor localizations.

As for the average national indicator of the proportion of stage IV (36.5%), the North Kazakhstan region stands out against this background - 14.3%; followed by the following regions: the city of Almaty (25.9%); Zhetysu (26.4%); Atyrau (26.5%); Almaty (27.3%); Aktobe (30.4%); Pavlodar (32.9%); the city of Shymkent, West Kazakhstan and Zhambyl regions (33.3%); Mangistau (34.6%); East Kazakhstan (35.5%); Kyzylorda (40.6%); the city of Astana (41.2%); Akmolra (45.0%); Kostanay (46.7%); Karaganda (48.8%). The most deplorable situation with neglect is in three regions of our country: Turkestan (52.3%); Abay (55.0%); and Ulytau (69.2%).

The total number of patients with malignant neoplasms registered with specialized oncology organizations of the republic continued to increase and by the end of 2023 amounted to 218,186 people, with an increase of 6.0% compared to the previous year (2022 – 205,822, +5.8%). The overall incidence rate of malignant neoplasms increased by 3.9%, from 1,055.3 to 1,096.4 per 100,000 population. This increase is due to both increased incidence and detection of the disease, as well as increased cancer patient survival.

Furthermore, statistical data on patients diagnosed with malignant neoplasms who have been under observation for 5 years or more and who continue to be monitored in 2023 showed that the number of patients under observation by oncology organizations in Kazakhstan for over five years continued to grow, reaching 117,616 at the end of the reporting year, an increase of 6.2% (2022: 110,790, an increase of 6.6%) (Form No. 7).

Another important clinical aspect worth noting is the coverage of patients diagnosed with PC in the Republic of Kazakhstan with specialized treatment.

In 2023, the number of hospitalizations for all types of malignant tumors in the country's oncology organizations amounted to 108,252 cases (2022: 101,095), representing a 7.1% increase compared to the previous year. This is due to the steady growth of the cancer patient population, improved standardization of oncology care, and the development of palliative and restorative services.

At the end of 2023, the absolute number of PC patients who completed specialized treatment was 338, with 384 patients continuing treatment. The following results were obtained in percentages by treatment methods and types. The overwhelming majority of patients received comprehensive treatment (57.1%), drug treatment alone (19.8%), surgery alone (19.2%), radiation therapy alone (0.6%), and chemoradiation (0.3%).

Next, regarding five-year patient survival. As for PC, at the end of 2023, 1,270 people were registered for follow-up care, or 6.4 per 100,000 population (at the end of 2022, 1,156 patients, or 5.9 per 100,000 population, respectively).

Moreover, in terms of mortality, PC has held the lead for many years. The mortality rate among observed cohorts in 2023 was 63.6%.

The five-year survival rate for patients with PC was 30.2% in 2023, which is lower than the previous year; in 2022 - 31.7% [12].

In summary, despite the increasing effectiveness of preventive screenings and improved early detection rates, PC continues to experience a relatively high incidence of new cases each year, with a five-year survival rate of only 30.2%, meaning only one in three survives the five-year mark. The paucity, variability, and subtlety of symptoms, along with their similarity to various non-core conditions, contribute to the neglect and progression of the disease, even during regular follow-up. This requires oncologists, primary care providers, and, of course, endocrinologists, radiologists, and ultrasound specialists to increase cancer awareness, inform the public about early symptoms that may indicate this pathology or the onset of proliferative changes, and implement high-tech diagnostic procedures, including for the purpose of differential diagnosis and, consequently, timely treatment. People at risk are advised to visit specialized specialists annually and, if necessary, undergo screening.

An epidemiological assessment of the PC situation in our country shows that there are sometimes significant regional differences not only in incidence rates but also in early diagnosis and mortality rates.

Therefore, this pathology continues to be a serious problem in modern clinical oncology.

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Pedagogical sciences

DEVELOPING INTERCULTURAL COMPETENCE THROUGH TOPONYMIC PHRASEOLOGICAL UNITS IN EFL CLASSROOM

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Abstract

The development of intercultural communicative competence has become one of the primary objectives of contemporary foreign language education. However, the integration of cultural content into English as a Foreign Language (EFL) instruction often remains fragmented and insufficiently methodologically grounded. This study investigates the pedagogical potential of toponymic phraseological units as a means of fostering intercultural competence in the EFL classroom. Toponymic phraseological units, which incorporate geographical names into idiomatic expressions, function as carriers of historical memory, sociocultural values, and symbolic meanings. Using a mixed-method research design, the study evaluates the effectiveness of a six-week instructional module implemented with undergraduate EFL students. The findings indicate that systematic analysis of such phraseological units significantly enhances students' cultural awareness, interpretative skills, and symbolic competence. The article argues that toponymic phraseological units represent an effective linguodidactic resource for integrating language and culture in a coherent pedagogical framework.

Keywords: *intercultural communicative competence, phraseological units, toponyms, EFL methodology, sociocultural competence, symbolic meaning.*

Introduction

The rapid expansion of intercultural communication in the context of globalization has transformed the aims of foreign language education. Language is no longer regarded merely as a grammatical system or a set of lexical units; rather, it is understood as a complex sociocultural phenomenon embedded in historical experience, collective memory, and symbolic representation. Consequently, the formation of intercultural communicative competence (ICC) has become a central objective in EFL classrooms worldwide.

Despite the recognition of intercultural competence as an essential educational goal, practical mechanisms for its systematic development remain insufficiently elaborated. Cultural instruction is frequently reduced to the presentation of isolated facts about traditions, customs, or national holidays. Such an approach often fails to integrate linguistic and cultural dimensions in a meaningful way. As a result, students may acquire linguistic accuracy without developing the interpretative and reflective skills necessary for effective intercultural communication.

*Phraseological units constitute one of the most culturally marked layers of vocabulary. They reflect national worldview, encode historical events, and preserve collective experiences in condensed linguistic form. Among them, toponymic phraseological units (TPUs) are particularly significant because they contain geographical names that function as cultural symbols. Expressions such as *when in Rome, do as the Romans do*, *meet one's Waterloo*, and *carry coals to Newcastle* illustrate how place names become embedded in metaphorical meanings that extend beyond their literal geographical reference.*

The present study seeks to explore the pedagogical value of toponymic phraseological units in developing intercultural competence among EFL learners. It addresses the following research questions:

- 1. In what ways do toponymic phraseological units contribute to the formation of intercultural competence?*
- 2. How can such units be methodologically integrated into EFL instruction?*
- 3. What measurable changes occur in students' intercultural awareness after systematic exposure to TPUs?*

Methods

This study employed a mixed-method research design combining quantitative and qualitative approaches. The use of both methods ensured a comprehensive analysis of instructional effectiveness and allowed for triangulation of data.

The research was conducted at al-Farabi Kazakh National University and involved 40 second-year undergraduate students majoring in foreign languages. The participants possessed intermediate (B1–B2) English proficiency levels. They were divided into two groups: an experimental group (20 students) and a control group (20 students). Both groups followed the same general curriculum; however, only the experimental group participated in the specialized instructional module focusing on toponymic phraseological units.

The experimental group completed a six-week instructional module specifically designed to integrate toponymic phraseological units into communicative language teaching. Each week focused on a thematic cluster of TPUs linked to historical events, cultural norms, or national symbols.

Instructional activities included semantic analysis of idiomatic meaning, etymological commentary, cultural-historical contextualization, comparative analysis between English and Kazakh phraseological units, role-play scenarios, and reflective discussions. Students were encouraged to explore the symbolic meanings embedded in geographical names and to examine how these meanings shape communicative interpretation.

For example, in analyzing the expression *when in Rome, do as the Romans do*, students examined the symbolic representation of Rome as a center of authority and tradition. The discussion extended beyond literal translation to include the concept of cultural adaptation and behavioral norms in intercultural contexts.

Similarly, the phrase *meet one's Waterloo* was studied through exploration of its historical origins and metaphorical transformation into a symbol of decisive defeat. Students reflected on how historical events become embedded in collective consciousness and subsequently reflected in language.

The expression *carry coals to Newcastle* provided an opportunity to analyze how industrial history shapes metaphorical meaning. Students investigated why Newcastle became associated with coal production and how this association generated an idiom expressing redundancy or unnecessary action.

The control group studied vocabulary through traditional lexical exercises without systematic cultural commentary or comparative analysis.

Data were collected using pre- and post-tests designed to measure intercultural awareness, interpretative ability, and understanding of culturally marked expressions. In addition, qualitative data were gathered through reflective journals, classroom observation, and semi-structured interviews.

The pre-test and post-test included scenario-based tasks requiring students to interpret phraseological units within communicative contexts. Reflective journals encouraged students to articulate their evolving understanding of cultural symbolism and linguistic meaning.

Quantitative data were analyzed using comparative statistical methods to determine significant differences between pre- and post-test results in both groups. Qualitative data were subjected to thematic analysis, focusing on categories such as cultural awareness, interpretative depth, reduction of literalism, and symbolic competence.

Results

The results demonstrate a clear positive impact of the instructional module on the development of intercultural competence in the experimental group (Table 1).

Table 1 – Pre-Test and Post-Test Scores on Intercultural Competence (0–100 scale)

Group	N	Pre-Test Mean (SD)	Post-Test Mean (SD)	Mean Gain	t-value	p-value
Experimental	20	62.4 (6.8)	81.7 (5.9)	+19.3	9.21	< .001
Control	20	63.1 (7.2)	68.2 (6.5)	+5.1	2.14	.045

Table 2 – Between-group comparison of gain scores

Group	Mean Gain	SD	t-value	p-value	Effect Size (Cohen's d)
Experimental	19.3	6.2	6.87	< .001	1.54 (large effect)
Control	5.1	5.8	-	-	-

Both groups began the study at comparable baseline levels (62.4 in the experimental group and 63.1 in the control group), indicating initial group equivalence prior to the intervention. Following the six-week instructional module, the experimental group demonstrated substantial improvement, with a mean gain of (+19.3) points, reflecting significant development of intercultural interpretative skills and deeper understanding of culturally embedded meanings. In contrast, the control group showed only minor progress (+5.1 points), which may be attributed to general language exposure rather than systematic cultural instruction. The large effect size (Cohen's $d = 1.54$) further confirms the high pedagogical effectiveness of the TPU-based module, while the statistical significance level ($p < .001$) indicates that the observed differences between groups are unlikely to have occurred by chance (Table 2).

The experimental group showed statistically significant improvement in post-test scores compared to pre-test results. Students demonstrated enhanced ability to interpret culturally embedded meanings,

identify historical references, and explain metaphorical extensions of toponymic elements. In contrast, the control group showed only minimal improvement, primarily limited to lexical recognition rather than cultural interpretation.

The difference between groups suggests that systematic integration of toponymic phraseological units contributes not only to vocabulary expansion but also to deeper intercultural understanding.

Reflective journals revealed substantial growth in students' cultural awareness. Initially, many participants attempted literal translations of phraseological units without considering historical or symbolic context. After the instructional intervention, students increasingly referred to cultural background knowledge and demonstrated greater sensitivity to pragmatic appropriateness.

Interviews confirmed that students perceived phraseological units as "cultural bridges" connecting language with history and identity. Classroom observation indicated higher engagement levels, increased participation in discussions, and more critical reflection on intercultural differences.

Discussion

The findings of this study confirm that toponymic phraseological units function as effective tools for integrating linguistic and cultural dimensions in EFL instruction. Unlike isolated cultural facts, TPUs embody culture within language itself, enabling simultaneous development of lexical competence and intercultural awareness.

Toponymic elements serve as cognitive anchors linking linguistic expression to geographical space, historical events, and collective memory. Through analysis of such units, learners engage in interpretative processes that go beyond surface-level comprehension. They learn to decode implicit cultural meanings and to recognize the symbolic power of language.

Moreover, comparative analysis between English and Kazakh phraseological systems enhances metacultural reflection. Students become aware not only of differences between cultures but also of shared mechanisms of metaphorization and symbolic representation. This awareness contributes to the development of intercultural mediation skills.

The results also suggest that phraseological competence is inseparable from intercultural competence. The ability to interpret and appropriately use idiomatic expressions reflects deeper understanding of cultural context and pragmatic norms.

Conclusion

This study demonstrates that the systematic integration of toponymic phraseological units into EFL instruction significantly enhances the formation of intercultural communicative competence. By exploring the cultural and historical dimensions embedded in geographical names, students develop interpretative flexibility, symbolic competence, and cultural sensitivity.

Toponymic phraseological units represent a valuable linguodidactic resource capable of bridging language and culture in a coherent pedagogical framework. Their use encourages reflective learning, critical thinking, and deeper engagement with linguistic meaning.

Future research may extend this model to different educational contexts, proficiency levels, and languages, as well as investigate long-term effects on intercultural communicative performance.

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Philological sciences

STUDY OF THE INTERRELATIONS BETWEEN LANGUAGE AND CULTURE

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Abstract

This article explores linguoculturology—the field that studies the interrelations between language and culture. The authors share their perspectives on the topic and analyze existing theories and scholarly works. The subject is closely linked to cultural studies. It is noted that linguoculturology is one of the main directions of national linguistics, and recent research shows that it has already emerged as an independent scientific discipline. New aspects arising at the intersection of language and culture lead to various approaches and diverse conclusions, reflecting scientific continuity and inheritance within the field. In foreign linguistics, scholars who have studied this area include Wilhelm von Humboldt, Ferdinand de Saussure, Edward Sapir, Benjamin Lee Whorf, Franz Boas, Noam Chomsky, Michael Halliday, and others; in Russian linguistics, Alexander Potebnja, Anna Maslova, Anna Wierzbicka, Viktor Vorobyov, and Vladimir Shaklein; in Azerbaijani linguistics, researchers such as A. Badalbayli, V. Ismayilov, N. Mammadova, F. Aliyeva and others have contributed to this field.

Introduction: Linguoculturology is the field at the intersection of linguistics and cultural studies. As its name suggests (from Latin *lingua* – language, *cultura* – culture, *logos* – science), this discipline studies how a nation's culture is reflected in language and its distinctive features. Its goal is to represent national identity through linguistic facts, as well as the people's cognitive and ethical categories, and to determine their functions and place within the system. A. Maslova explains this field as follows: "Linguoculturology is the science that emerged at the intersection of linguistics and cultural studies, investigating the manifestations of a nation's culture as reflected and formed in language" [Maslova, 2010, p. 37]. The scholar notes that there are several types of linguoculturology, each consisting of separate linguocultural units. Its main characteristics are as follows:

Reflection of folk culture – Through language, a people's customs, values, and worldview become visible.

Manifestation of national identity– Linguistic facts reveal the moral and cultural characteristics of the nation.

Functional systematicity – Cultural and linguistic elements operate in an interconnected and systematic manner.

Presence of unified structures– Linguocultural units serve as distinct objects of study within each area.

New perspectives– The interaction between language and culture can be explored more deeply and from different angles.

In linguoculturology, the objects of study are units at various levels of language that carry cultural meaning. The following elements are primarily examined in this field:

Non-equivalent vocabulary and lacunas – Words and concepts closely tied to a people's lifestyle, everyday life, history, and worldview, which have no full equivalents in other languages. These units reflect the uniqueness of national culture and require special explanation during translation.

Mythological language units – Concepts related to archetypes, mythologems, customs, and rituals. These units reflect a people's early worldview, cosmogonic ideas, and collective subconscious. The aim here is not the entire myth, but identifying its core elements stabilized in language.

Paremiological lexicon – Through proverbs and sayings, these units convey a people's life experience, moral values, behavioral norms, and attitudes toward the world. Paremiological units serve as carriers of cultural memory.

Phraseological lexicon – Fixed expressions and idioms preserve a people's national mentality, emotional attitudes, and cultural stereotypes. Through phraseology, myths, customs, and historical events are kept alive in linguistic memory.

Standards, stereotypes, and symbols – Acting as cultural codes, they shape national models of understanding the world. Standards ensure that events and objects are evaluated according to national measures, stereotypes reflect stable cultural perceptions, and symbols convey deeper layers of meaning.

Metaphors and linguistic imagery – One of the main tools revealing the connection between language and culture. Through metaphorical thinking, abstract concepts are expressed via concrete images, and cultural values are presented in linguistic form.

Stylistic means of language – Lexical, syntactic, and stylistic devices that create emotional expressiveness. These means demonstrate how culture manifests in language, in what forms, and with what functions.

Speech style (manner of speaking) – Encompasses the cultural-linguistic norms that determine to whom, where, and under what circumstances it is appropriate to speak. Social status, age, type of relationship, and communicative situation play a central role.

Features of speech etiquette – Social and cultural rules covering behavioral patterns such as greetings, forms of address, expressions of gratitude, apologies, etc. Speech etiquette reflects the national mentality and cultural norms of behavior in language.

These elements are studied not as a single, homogeneous system but rather as a heterogeneous set, presented directly as carriers of cultural concepts.

In linguoculturology, language is examined both in terms of words and speech styles; that is, language itself is treated as the object of study.

Mythologized language units – Archetypes, mythologems, customs, and rituals. The primary goal is not the entire myth but to identify its key elements: the image, the situation, and the "main hero." An archetype is a stable image formed in the subconscious and widely present in culture.

Paremiological lexicon (proverbs and sayings) reflects the people's hardships, needs, living conditions, and moral worldview.

Phraseological lexicon reflects the national mentality and culture, preserving ideas and perspectives related to myths, customs, and rituals.

In other words, linguoculturology studies language as a carrier of culture, revealing a people's worldview starting from individual words.

Standards (Etalons) – Units that reflect a people's worldview and national model of understanding the world. For example: "strong as an ox" or "like the bulging eyes of a calf" (a beauty standard among the Kyrgyz). They measure worldly events according to national-typical proportions and enter language through concrete comparisons: "cheerful as a bird," "angry as a wolf," etc. Any idea, especially regarding human traits or measurements of the world, can serve as a standard.

Metaphors and linguistic imagery – Important units that illustrate the relationship between words and culture; they carry essential information and reflect cultural values.

Other research areas in linguoculturology:

Stylistic structure of language – Examines how existence and reality are expressed in various forms within a language.

Speech style and behavioral norms – Studies expressions and behavioral patterns fixed in nominative, stylistic, and grammatical units.

Thus, linguoculturology analyzes all the subtleties of culture and national worldview through language.

Linguoculturology and speech etiquette – As Osip Mandelstam noted, it studies the concept of "cultural politeness." Speech etiquette demonstrates the social-cultural rules of verbal behavior that arise according to people's social and psychological roles and the formal or informal context of communication.

Linguoculturology studies the "language – culture – human" connection and its development is closely related to ethnolinguistics and other achievements in linguistics.

Anna Wierzbicka describes the field as follows: "Linguoculturology is the science that unites and systematically investigates cultural and linguistic units. It examines the use of cultural values as reflected and manifested in language, thereby forming the concept of the 'linguacultureme'" [Wierzbicka, 1992,

p. 11]. She emphasizes that each language possesses its own national uniqueness; not only the natural environment and culture but also the national character of its speakers are reflected in language. The lexical composition of different languages mirrors the core values of their respective cultural communities. Such research is valuable not only for linguists but also for anthropologists, psychologists, and philosophers.

In the modern era, linguoculturology develops in parallel with cultural studies and examines the boundary between language and culture.

V. Vorobyov introduced linguoculturology as a new discipline within linguistics. He states: "Linguoculturology is a complex science; it studies the interaction between language and culture, combining cultural and linguistic content and presenting it systematically" [Vorobyov, 2005, pp. 36–37].

According to Wilhelm von Humboldt, language is both an activity and a powerful tool for creativity; it is a primary indicator of a nation's spiritual existence. The main idea is that culture manifests itself through language, and humans acquire their culture via language.

Alexander Potebnja also emphasizes the creative nature of language: "The more language embodies an active character, the more it carries the essence of creativity" [Potebnja, 2007, p. 72]. For him, language is a form of aesthetic creation. Potebnja considers myth as analogous to language—the myth in early communal societies represents the perception of the world, combining it with ritual and aesthetic elements.

Linguoculturology remains a relevant and scientifically valuable field within linguistics. In Russian linguistics, systematic research in this area began in the late 19th century, while in English linguistics it started developing during the transitional period of the 19th–20th centuries. In Azerbaijani linguistics, problems of linguoculturology have been studied since the late 20th century within the framework of modern national linguistics. New aspects emerging at the intersection of language and culture give rise to diverse approaches and different conclusions, reflecting scientific continuity and inheritance in the field. Over the past ten to fifteen years, numerous studies and monographs on language and culture have been published, solidifying scientific conclusions regarding the characteristics, objects, and subjects of linguoculturology. Currently, linguoculturology is one of the main directions of national linguistics, and recent research shows that it has already taken shape as an independent scientific discipline.

This field is studied from various perspectives:

Manifestation of language and ethnos in cultural units – Russian linguistics: Alexander Potebnja, Anna Wierzbicka, Viktor Vorobyov; English linguistics: Wilhelm von Humboldt, Edward Sapir, Benjamin Lee Whorf; Azerbaijani linguistics: A. Badalbayli, V. Ismayilov.

Ethnocultural information in ashik and jirau poetry – Russian linguistics: Vladimir Shaklein; English linguistics: Franz Boas, Noam Chomsky; Azerbaijani linguistics: N. Mammadova, F. Aliyeva.

Etymology of ethnocultural names – Russian linguistics: Anna Maslova, Alexander Potebnja; English linguistics: Ferdinand de Saussure, Michael Halliday; Azerbaijani linguistics: A. Badalbayli, N. Mammadova, F. Aliyeva.

Manifestation of culture in language – The expression of national cultural features through language. Viktor Vorobyov notes that linguoculturology is closely connected with ethnolinguistics and dialectology and lays the groundwork for forming new scientific approaches to studying language in a cultural context [Vorobyov, 2005, p. 142].

Anna Maslova points out that linguoculturology studies not only the structural aspects of language but also its connection with individual thought, speech, and cultural-practical activity, leading to new research directions. Among these directions, linguoculturology, anthropological linguistics, and the study of culture through language hold a special place [Maslova, 2010, p. 221].

Today, the extensive discussion of linguoculturology as one of the key means of understanding the national language in recent studies indicates that this scientific field has already begun to take shape. "Linguoculturology is the scientific discipline that examines ethnocultural and ethnopsychological factors, as well as the national-cultural semantic components in language, through the lens of cultural studies. It reflects the contemporary use of language and presents national uniqueness in accordance with the requirements of the time, without linking it to any ideology. In this regard, the language–nation–culture triad constitutes the primary object of study in linguoculturology."

Anna Wierzbicka, who investigates translation-related linguoculturological problems, states: "Linguoculturological features are distinctive traits that are organically connected with national culture and cannot be separated from it" [Wierzbicka, 1992, p. 158]. The study of linguistic facts from a linguoculturological perspective primarily serves to identify universal humanitarian, cultural, and civilizational aspects across languages. Since events in nature and society, social consciousness, and customs are

reflected in language, the process of naming and its formation features are analyzed from a linguoculturological standpoint.

As noted above, culture forms the foundation of a people's national-mentality values, and these values are reflected in the essence of language. Reality is expressed and perceived through the power of language in a figurative manner. This very point forms the basis of linguoculturology, the science that targets the intersection of language and culture. At the same time, language is an integral component of culture and is considered a spiritual entity within linguoculturology. In other words, a language embodies a nation's worldview, customs and traditions, distinctive features of national culture, and spiritual life. Language develops in close connection with culture, while simultaneously shaping, enriching, and preserving it.

Linguoculturology recognizes the totality of cultural and linguistic units and studies them systematically, examining the operative mechanisms of cultural values as reflected in and manifested through language. In this regard, it functions as a scientific discipline that unites elements of language and culture around a central focus.

Consequently, a new domain of language has emerged at the intersection of linguistics and cultural studies. This rich linguistic field, which reflects the deep layers of national worldview, customs, and cultural consciousness, has not yet been fully and comprehensively explored. This presents an important scientific task for future researchers.

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Technical sciences

SMART CITY TECHNOLOGY, PROBLEMS OF STANDARDIZATION AND INTRODUCTION IN CIRCULATION

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«АҚЫЛДЫ ҚАЛА» (SMART CITY) ТЕХНОЛОГИЯСЫ, СТАНДАРТТАУ ЖӘНЕ АЙНАЛЫМҒА ЕНГІЗУ МӘСЕЛЕЛЕРІ

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Abstract

This article considers the concept of a "smart city" as a general vector of further socio-economic development of cities, which can lead to the creation of a qualitatively new standard of living for the population with appropriate improvement of approaches to city management.

Аннотация

Бұл мақалада "ақылды қала" түсінігі қалаларды жалпы әлеуметтік-экономикалық дамытудың негізгі векторы ретінде қарастырылады, бұл қаланы басқару тәсілдерін тиісті түрде жетілдіре отырып, халықтың өмір сүруінің сапалы жаңа деңгейін құруға әкелуі мүмкін.

Keywords: "smart city", intellectual potential of the territory, "intelligent" management, priority areas of smart city development.

Түйінді сөздер: "ақылды қала", аумақтың зияткерлік әлеуеті, "зияткерлік" басқару, "ақылды" қаланы дамытудың басым бағыттары.

Қоғамға Төртінші Өнеркәсіптік Революция элементтерін кеңінен енгізуге негізделген ҚР Президентінің 2018 жылғы 10 қаңтардағы Қазақстан халқына Жолдауы негізгі он бағыттан тұрады, ал оның бір бағыты, яғни оныншы бағыты қазіргі кезеңдегі жахандық даму сипатындағы «Ақылды қала» (Smart City) технологиясын енгізуге арналған. Нақты тәжірибелік міндеттер қойылған бұл кешенді бағдарламаның барлық қазақстандықтар үшін маңызы өте зор, соның ішінде осы оныншы бағыттың қалалық ортаны ақылды стандарттар көмегімен басқарудың кешенді түрін енгізуге бағытталуының қазіргі таңда маңызы өте зор [1].

Осы бағытта елімізде бірқатар жұмыстар да атқарылуда, ол туралы Үкімет отырыстарында тиісті баяндамалар да жасалып келеді. Атап айтар болсақ, Smart City концепциясы барлық қалалық қызметтердің тиімділігін арттыруға бағытталған. Smart City миссиясының негізі - адам және оның қажеттіліктерін қанағаттандыру. Ақылды қаланың негізгі сипаттамалары - жайлылық, қауіпсіздік, тиімділік және экологиялық. «Цифрлық Қазақстан» мемлекеттік бағдарламасының негізгі көрсеткіштерінің бірі - еліміздің бес ірі қалаларында - Smart Astana, Smart Karaganda, Smart Ontystuk, Smart Almaty, Smart Aktobe қалаларында «Smart City» технологияларын дамытуды көздейді» [2].

Қазақстан халқына арналған Жолдауда да бұл тақырып бекерден-бекер көтерілмеген, өйткені қазіргі уақытта «Ақылды қала» немесе «Smart city» технологиялары цифрлық

экономиканың үлкен бір бөлігін құрайды, және де цифрлық экономиканың өзі сияқты жаһандық сипатта, сондықтан оны іске асыру жеке бір қала деңгейінде ғана емес, мемлекеттік деңгейде жүргізілуі тиіс. Қазіргі уақытта бұл бағыттағы жұмыстарды дүние жүзінің көптеген алдыңғы қатарлы елдері іске асыруда [1].

БҰҰ [3] мәліметтері бойынша 2014 жылы жер бетіндегі халықтың 54% қалаларда тұрған екен. 1950 жылы бұл көрсеткіш барлығы тек 30% болған, ал 2050 жылға қарай әлем халқының 66% қалаларда тұрады деп болжануда. Егер осы мәселені аймақтар бойынша қарастыратын болсақ, онда 2014 жылы қала халқы Солтүстік Америкада 82%, Латын Америкасы мен Кариб елдері бассейнінде - 80%, Европада - 73%, ал Африка мен Азия елдерінде бұл көрсеткіш тиісінше 40% және 48% құраған. Ал, көршілес Ресей елінде халық санына шаққанда қала халқының саны 73% құрайды екен. Осы жағдай біздің елімізде 54,1 және 45,9 пайыздық қатынаста.

Сондықтан, бұл бағыт өте қызықты, әрі қазіргі таңда қоғамдағы үлкен мәселелердің бірі деп айтуға болады. Өйткені біз осыған дейін, «ақылды» деген сөзді адамдарға қатысты (мысалы, ақылды бала, ақылды қыз), сонымен қатар жан-жануарларға қатысты (мысалы, ақылды мысық, ақылды ит және т.б.) айтып келсек, соңғы кездері бұл «ақылды» сөзі техникаға, бізді қоршаған орта объектілеріне де қатысты да айтыла бастады (мысалы, ақылды машина, ақылды пәтер және т.б.). Осындай терминдер соңғы уақытта біздің қоғамға кеңінен ене бастады.

Қазіргі уақытта қоғам дамуында Интернет әлемі үлкен орын алады. Интернет мүмкіндіктерін пайдалану арқылы (Интернет әлемі, IoT) қоғамды дамытудың ең танымал бағыттарының бірі – «ақылды қала» (Smart City) тұжырымдамасы. «Ақылды қала» тұжырымдамасының фундаментальдық принципі болып, қалалық ортаға ақпараттық технологияларды енгізу табылады. Бұл көзқарас мемлекет пен қоғамның өзара қарым-қатынасын жақсарттады, қалалық қызметтердің сапасы мен тиімділігін арттырады, және осылардың барлығы бірге халықтың өмірін сапалы түрде өзгертеді. Сондай-ақ «ақылды қала» принциптері мен тетіктерін енгізу арқылы қаланың тұрақты дамуына бірыңғай көзқарас қалыптасады [4].

«Ақылды қала» (Smart City) технологияларын құрудың басты мақсаты – ол, қаланың инфрақұрылымын жақсарту арқылы онда тұрып жатқан азаматтардың өмірге қанағаттану деңгейін арттыру.

«Ақылды қала» тұжырымдамасы үш негізгі базалық параметрлермен сипатталады:

- технологиялық;
- зияткерлік;
- өмір стиліне енгізілетін өзгерістер.

«Ақылды қала» тұжырымдамасының іске асырылуы экологиялық таза, қауіпсіз, энергия көздеріне бай, кең мүмкіндіктерді ашып, адамдардың жайлы өмір сүруін қамтамасыз етуі тиіс.

Зияткерлік жаңғыртуды қажет ететін басым салалар арасында алғашқы орындарды мемлекеттік басқару, қаланың инфрақұрылымы және экономика саласы алады. Осы секторларды дамытудың негізгі бағыттары төменде кестеде келтірілген.

Кесте 1 - «Ақылды қала» (Smart City) технологиясын дамытудың маңызды бағыттары

Инновациялық экономика	Қалалық инфрақұрылым	Мемлекеттік басқару
Өнеркәсіптегі, кластерлердегі, қалалық аудандардағы инновациялар	Көлік қызметі	Азаматтарға әкімшілік қызмет көрсету
Ақылды жұмыс күші: білім беру және жұмыспен қамту	Энергетика және коммуналдық қызметтер	Өкілдік және тікелей демократия
Білімге негізделген компаниялар құру	Қоршаған ортаны қорғау / қауіпсіздік	Азаматтарға арналған қызметтер: өмір сүру сапасы

Мысалы, осы бағыттардағы тұжырымдамасымынадай белгілерде көрінуі мүмкін. Инновациялық экономика өздігінен жеткілікті және табиғи-көмірсутек ресурстарынан тәуелсіз болу керек. Қалалық инфрақұрылымға экономикалық және жаңартылатын энергия көздерін енгізіп пайдалану қажет. Мемлекеттік қызмет салаларында капиталдың, қаржылық және зияткерлік, сонымен қатар адамның бәсекеге қабілеттілігін арттыру үшін жұмыстар жасалуы керек [4].

«Ақылды қала» дамытудың жол картасы

«Ақылды қала» тұжырымдамасын дамытудың жол картасы осы тұжырымдаманы іске асырудың мынадай жолын ұсынады. Осы бағытта қабылданған Қазақстан Республикасының стандарты, яғни ҚР СТ «Смарт қала. Сөздік» құжатында «ақылды қала» терминіне байланысты бірқатар анықтамалар берілген.

Алдымен, «Ақылды қала» тұжырымдамасы не үшін қажет? деген сұрақ туындайды.

Біріншіден, қалалар өз қоғамын, ортасын зерделеп зерттеулері керек. Алға мақсат қоймай, табысқа жету мүмкін емес, сондықтан азаматтар мен бизнестің қажеттіліктерін, олардың мүдделерін, ерекшеліктерін, ойлау әдісін, білім деңгейін, жас құрылымын және т.б. қажеттіліктерін зерттеу керек, яғни алдымен халық «ақылды қаланың» не үшін қажет екенін түсінуі керек.

Сонымен «ақылды қала» технологиясының қажеттілігі анықталғаннан кейін, бұл тұжырымдаманы қалай іске асыруға болады? деген заңды сұрақ та туындайды.

Екіншіден, «неге қажет», «не үшін қажет» деген сұрақ анықталған кезде концепциясыны іске асырудың «қалай», «қандай жолмен» деген стратегиясын жасау керек. Атап айтқанда, «ақылды қала» бастамалары қалай таралады, мұндай саясаттың мақсаттары мен міндеттері қандай?

«Ақылды қала» шарасын құруға кім мүдделі?

«Ақылды қаланың» артықшылығы, ең алдымен, халықтың өмір сүру жағдайларын жақсартуға бағытталған. Сондықтан, ең алдымен бұл идеяны азаматтар қолдауы керек. Олар оны дамытуға және жүзеге асыруға қызығушылық танытуы керек, сонымен қатар процеске қатысуы да қажет. Мысалы, процестердің ашықтығын арттыру, электрондық үкімет жүйелері арқылы басқару мүмкіндіктерін кеңейту және т.б.

Дегенмен, жоғарыда аталған бағыттар бойынша жұмысқа кіріспес бұрын, алдымен қалалық қоғамдастықтың негізін түсінген жөн. Қазіргі кездегі оның жағдайы қандай, қаланың географиялық шекаралары, көршілес аудандармен өзара қарым-қатынастары және т.б.

Ұсынылған алгоритм бойынша жүргізілетін жұмыс қоғамның үдерістерін зерделеуге, халықтың қажеттіліктерін анықтап, оларға қол жеткізудің мақсаттары мен құралдарын қалыптастыруға мүмкіндік береді [4].

Елімізде «ақылды қала» тұжырымдамасын стандарттау мәселесі қандай, осыған біраз тоқталайық.

Біздің елімізде де «ақылды қалалар» құру бойынша жобалар құрастырылып, осы бағытта бірқатар жұмыстар жүргізілуде.

2016 жылы «Астана Innovations» АҚ базасында «ТК 34 (TK34/SC2) Ақпараттық-коммуникациялық технологиялар саласындағы «Ақылды қала» кіші комитеті құрылды, ол бүгінде Астана қаласын ақылды қалалар қатарына қосу жұмыстарын жасауда.

Бүгінгі күні Қазақстанда халықаралық стандарттар негізінде әзірленген «Ақылды қала» саласында стратегиялық және жүйелік мәселелерді шешудің нормативтік және техникалық құжаттары бар. Қазіргі таңда Smart City жобаларын іске асыруды жеңілдету мақсатында қаланың басшылары үшін 9 негізгі ұлттық стандарт бекітілген, соның ішінде Smart City компоненттерін жоспарлау және енгізу стандарты да бар. Нәтижесінде 2015 жылы 1 негізқалаушы стандарт, ал 2016 жылы 8 негізқалаушы стандарт қабылданған.

Бұлардан басқа 7 негізқалаушы стандарттар құрастыру бойынша да жұмыстар жүргізілуде. Сонымен қатар, «Зерде» ұлттық инфокоммуникациялық холдингі АҚ мемлекеттік стандарттау Жоспарына негізқалаушы стандарт құрастыру жұмыстарын жоспарлап орындап келеді.

Стандарттарға қойылатын талаптар үрдістерге негізделген: тұжырымдамаға деген қызығушылық артып келеді, жаңа жобалар пайда болады, олардың арасындағы келісу болмайды. Бірыңғай критерий білімді қорытуға, күш-жігер мен идеяларды біріктіруге мүмкіндік береді, қандай қаланы «ақылды» деп қарастырады және оның құрылысын тездетеді. Сонымен бірге, стандарттар қоғамның ағымдағы қажеттіліктерін қанағаттандыру үшін жоспардың іске асырылу үрдісінде өзгеріп отырулары тиіс [5].

Осы қабылданған ұлттық стандарттар негізінде еліміздің бірнеше қалаларында, атап жоғарыла келтірілгендей Астана, Алматы, Шымкент, Ақтөбе және Қарағанды қалаларында «ақылды қала» тұжырымдамасын енгізу қолға алынуда.

Қалалардың интеллектуалды дамуға мүмкіндіктері болуы үшін M2M технологиясын және білім беруді жаңғырту қажет.

Machine-to-Machine (M2M) - машинааралық ақпарат алмасу немесе оның бір жақты таратылуы. Технология «болашағы зор» және «ақылды қала» тұжырымдамасында кең ауқымды қосымшаларды күтеді. Мысалы, «ақылды» үй сенсорларында ауа температурасы, жарықтандыру деңгейі және т.б. «Ақылды» үйден басқа M2M шешімдері көптеген жүйелерге:

яғни төлемдер, қауіпсіздік, навигация, коммуналдық қызметтер, ЖКХ, сауда, денсаулық сақтау және т.б. көмектеседі [6].

Тұжырымдама қаланы дамытудың мынадай міндеттерін кешенді шешуге бағытталған, яғни:

1. Қалалық инфрақұрылымды кешенді жаңғырту;
2. Аймақтың инвестициялық тартымдылығын арттыру;
3. Қалалық ортаның өңірлік инновациялық жүйесін дамыту;
4. Қала әкімдігінің шешім қабылдау үдерісін оңтайландыру;
5. Басқару стилін жаңғырту;
6. Қаланың тұрғындарының өмір сүру сапасын жақсарту, оның ішінде жұмыс істеу, оқу және демалу үшін қолайлы жағдайлар жасау;
7. Халықты ақпараттандыру;
8. Қоғамдық қауіпсіздік деңгейін көтеру.

Сонымен, мақаланың соңында мынадай қорытынды жасауға болады, яғни жайлылық, қауіпсіздік, тиімділік және экологиялық сияқты кешенді даму қажеттіліктерін және көптеген ұйымдар мен кәсіпкерлердің сұраныстарын есепке ала отырып, әртүрлі қалалық қызметтердің ағымдағы қажеттіліктерін және даму перспективаларын ескеретін «Smart City» технологиясын енгізу «Төртінші өнеркәсіптік революция жағдайындағы дамудың жаңа мүмкіндіктері» атты Жолдаудың оныншы бағытында қарастырылған талаптарға сай келеді.

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THE PROCESS PATH OF ENTERPRISE MANAGEMENT: ADVANTAGES AND PROSPECTS**Amangeldy Farhad***Student Taraz University named after M.H.Dulati***Oksikbay Nurdaulet***Student Taraz University named after M.H.Dulati***Orazgaliev Dauren***Student Taraz University named after M.H.Dulati***Kauymbaev Rakhimzhan***PhD, Associate Professor,**Taraz University named after M.H.Dulati***ПРОЦЕССНЫЙ ПУТЬ УПРАВЛЕНИЯ ПРЕДПРИЯТИЕМ: ПРЕИМУЩЕСТВА И ПЕРСПЕКТИВЫ****Амангелді Фархад***студент Таразского университета им.М.Х.Дулати***Оксікбай Нурдаулет***студент Таразского университета им.М.Х.Дулати***Оразгалиев Даурен***студент Таразского университета им.М.Х.Дулати***Кауымбаев Рахимжан***PhD, доцент Таразского университета им.М.Х.Дулати***Abstract**

The article examines the process path of enterprise management as a modern management concept aimed at improving the efficiency of an organization in a dynamic external environment. The essence of the process approach, its distinctive features in comparison with the functional management model, as well as the key principles of building a business process system are revealed.

Аннотация

В статье рассматривается процессный путь управления предприятием как современная управленческая концепция, ориентированная на повышение эффективности деятельности организации в условиях динамичной внешней среды. Раскрывается сущность процессного подхода, его отличительные особенности по сравнению с функциональной моделью управления, а также ключевые принципы построения системы бизнес-процессов.

Keywords: process approach; enterprise management; business processes; management efficiency; organizational structure; process optimization; digitalization; competitiveness; strategic development; sustainable development.

Ключевые слова: процессный подход; управление предприятием; бизнес-процессы; эффективность управления; организационная структура; оптимизация процессов; цифровизация; конкурентоспособность; стратегическое развитие; устойчивое развитие..

Введение. В условиях высокой конкуренции, цифровой трансформации и постоянных изменений рыночной среды предприятия вынуждены искать новые подходы к управлению. Одним из наиболее эффективных и востребованных направлений является процессный путь управления предприятием. Традиционная функциональная модель управления постепенно уступает место процессному подходу, ориентированному на создание ценности для потребителя через эффективное управление бизнес-процессами. В отличие от традиционного функционального подхода, процессное управление ориентировано на сквозные бизнес-процессы, создающие ценность для потребителя.

Процессный подход получил широкое распространение благодаря развитию стандартов менеджмента качества, в частности в International Organization for Standardization (ISO), а также исследованиям в области реинжиниринга бизнес-процессов.

Сущность процессного подхода. Процессный путь управления - это система организации деятельности предприятия, при которой основным объектом управления становятся бизнес-процессы, а не отдельные подразделения.

Бизнес-процесс - это совокупность взаимосвязанных действий, преобразующих входы (ресурсы, информацию, материалы) в выходы (продукцию или услуги), представляющие ценность для клиента.

Согласно стандарту ISO 9000, бизнес-процесс - это совокупность взаимосвязанных или взаимодействующих видов деятельности, преобразующих входы в выходы. Данный подход базируется на следующих принципах:

- ориентация на потребителя;
- системность управления;
- распределение ответственности за результаты;
- измеримость и контроль показателей;
- непрерывное улучшение.

Значительный вклад в развитие концепции процессного управления внесли Michael Hammer и James Champy, разработавшие теорию реинжиниринга бизнес-процессов, а также Joseph Juran, сформулировавший основы управления качеством.

Таблица 1. Отличие процессного и функционального управления

Критерий	Функциональный подход	Процессный подход
Структура	По отделам	По процессам
Ответственность	Разделена по подразделениям	Назначается владелец процесса
Ориентация	На внутренние задачи	На клиента и результат
Гибкость	Низкая	Высокая
Контроль	По функциям	По показателям процесса

Функциональная модель эффективна в стабильной среде, однако при росте сложности бизнеса она приводит к разобщенности подразделений и снижению управляемости.

Преимущества процессного пути управления.

1) Повышение прозрачности деятельности.

Формализация и описание процессов позволяют выявлять дублирование функций, узкие места и потери ресурсов.

2) Улучшение качества продукции и услуг.

Благодаря стандартизации и контролю показателей снижается вероятность ошибок и брака, т.е. стандартизация процессов способствует снижению дефектов и повышению удовлетворенности клиентов.

3) Рост управляемости и ответственности.

Назначение владельцев процессов усиливает персональную ответственность за достижение необходимых результатов.

4) Сокращение и снижение затрат.

Оптимизация процессов снижает издержки, устраняет лишние операции и уменьшает время выполнения задач, т.е. минимизируются издержки и сокращаются временные затраты.

5) Повышение гибкости и адаптивности предприятия.

Процессная модель легче адаптируется к изменениям внешней среды, т.е. обеспечивается более быстрая адаптация к изменениям внешней среды.

6) Основа для цифровизации процессов производства.

Автоматизация и внедрение ERP-, CRM- и BPM-систем невозможны без четко описанных процессов.

Этапы внедрения процессного управления:

- Идентификация ключевых бизнес-процессов;
- Описание и моделирование процессов;
- Назначение владельцев процессов;
- Определение KPI;
- Автоматизация;
- Непрерывное совершенствование.

Часто внедрение сопровождается применением стандартов качества, например серии ISO 9000 Система менеджмента качества, разработанных International Organization for Standardization.

Перспективы развития процессного управления. В условиях цифровой трансформации процессное управление приобретает новые направления развития:

- Интеграция с цифровыми технологиями - использование BPM-систем, ERP-платформ и аналитики больших данных.

- Развитие бережливого производства (Lean) - минимизация потерь и непрерывное совершенствование процессов.

- Переход к гибридным моделям управления - сочетание процессного, проектного и продуктового подходов.

- Использование искусственного интеллекта для автоматизации анализа и оптимизации процессов.

- Принятие управленческих решений все чаще основывается на процессной аналитике в реальном времени.

Процессное управление становится фундаментом стратегического развития предприятия и ключевым элементом современной системы менеджмента. Концепции Lean и Kaizen усиливают процессное управление за счет минимизации потерь и непрерывного улучшения.

Проблемы внедрения. Несмотря на очевидные преимущества, внедрение процессного управления связано с рядом сложностей:

- сопротивление персонала организационным изменениям;
- необходимость пересмотра организационной структуры;
- значительные финансовые затраты;
- недостаточная квалификация сотрудников в области процессного анализа.

Успешная реализация требует поддержки высшего руководства и формирования культуры постоянных улучшений.

Заключение.

Процессный путь управления предприятием является эффективным инструментом повышения конкурентоспособности, прозрачности и управляемости организации, ориентированную на повышение эффективности, качества и конкурентоспособности организации. В условиях цифровой экономики он становится не просто альтернативой функциональной модели, а необходимым условием устойчивого развития.

Перспективы развития данного подхода связаны с цифровизацией, аналитикой данных и интеграцией с современными управленческими концепциями. Предприятия, ориентированные на процессы, получают стратегическое преимущество, обеспечивая высокое качество, оптимальные затраты и удовлетворенность клиентов.

Таким образом, процессное управление - это не временная управленческая тенденция, а фундамент современной системы менеджмента.

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STUDY OF THE ABRASION RESISTANCE OF SEWING THREADS USED IN THE INDUSTRY

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ИССЛЕДОВАНИЕ СТОЙКОСТИ К ИСТИРАНИЮ ШВЕЙНЫХ НИТОК, ПРИМЕНЯЕМЫХ В ПРОИЗВОДСТВЕ

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Abstract

This paper examines the abrasion resistance of sewing threads used in industrial production. A comparative analysis was conducted of threads of various fiber compositions—cotton, polyester, and reinforced threads. Wear resistance was assessed using laboratory tests with repeated cyclic friction, determining the number of cycles before rupture and the degree of reduction in tensile strength. It was found that synthetic and reinforced threads exhibit higher resistance to mechanical stress compared to cotton threads, which contributes to increased seam strength and a longer service life of finished products. The obtained results can be used to inform the selection of sewing threads for various operating conditions.

Аннотация

В работе исследована стойкость к истиранию швейных ниток, применяемых в промышленном производстве. Проведён сравнительный анализ ниток различного волокнистого состава — хлопчатобумажных, полиэфирных и армированных. Оценка износостойкости осуществлялась на основе лабораторных испытаний при многократном циклическом трении с определением количества циклов до разрыва и степени снижения разрывной прочности. Установлено, что синтетические и армированные нитки обладают более высокой устойчивостью к механическому воздействию по сравнению с хлопчатобумажными, что способствует повышению прочности швов и увеличению срока службы готовых изделий. Полученные результаты могут быть использованы при обоснованном выборе швейных ниток для различных условий эксплуатации.

Keywords: sewing thread, abrasion resistance, wear, mechanical strength, polyester threads, reinforced threads, textile manufacturing, seam quality

Ключевые слова: швейные нитки, стойкость к истиранию, износ, механическая прочность, полиэфирные нитки, армированные нитки, текстильное производство, качество шва

Швейные нитки являются основным средством соединения деталей верха и низа обуви. При производстве обуви швейные нитки испытывают значительные истирающие воздействия, которые приводят к частичному их разрушению, уменьшению прочности, а затем и разрыву. Требование стойкости к истиранию весьма существенное, но оно, к сожалению, не обеспечено определенными нормативами и конкретными данными по износу при шитье.

Важным показателем, характеризующим технологические свойства ниток, является их износостойкость при самоистирании, когда в качестве абразивов используются испытываемые нитки.

Поэтому исследование износостойкости ниток при самоистирании является актуальной задачей, так как в условиях современного обувного производства при скорости работы машин до 2500 – 3000 об/мин нитки испытывают, наряду с другими воздействиями (удары, многократные циклы растяжения и изгиба и др.) истирание и самоистирание.

Нами исследована износостойкость ниток при самоистирании и определено количество циклов до разрыва в зависимости от массы подвешиваемого груза, угла между ветвями α , вида ниток. А так же определена зависимость стойкости ниток к истиранию от разрывной нагрузки при растяжении. Построены графики: «Зависимость стойкости ниток самоистиранию

от угла между ветями» и зависимость стойкости ниток самоистиранию от них разрывной нагрузке.

Таким образом, исследование стойкости к истиранию позволит определить некоторые показатели характеризующих технологических свойства ниток.

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